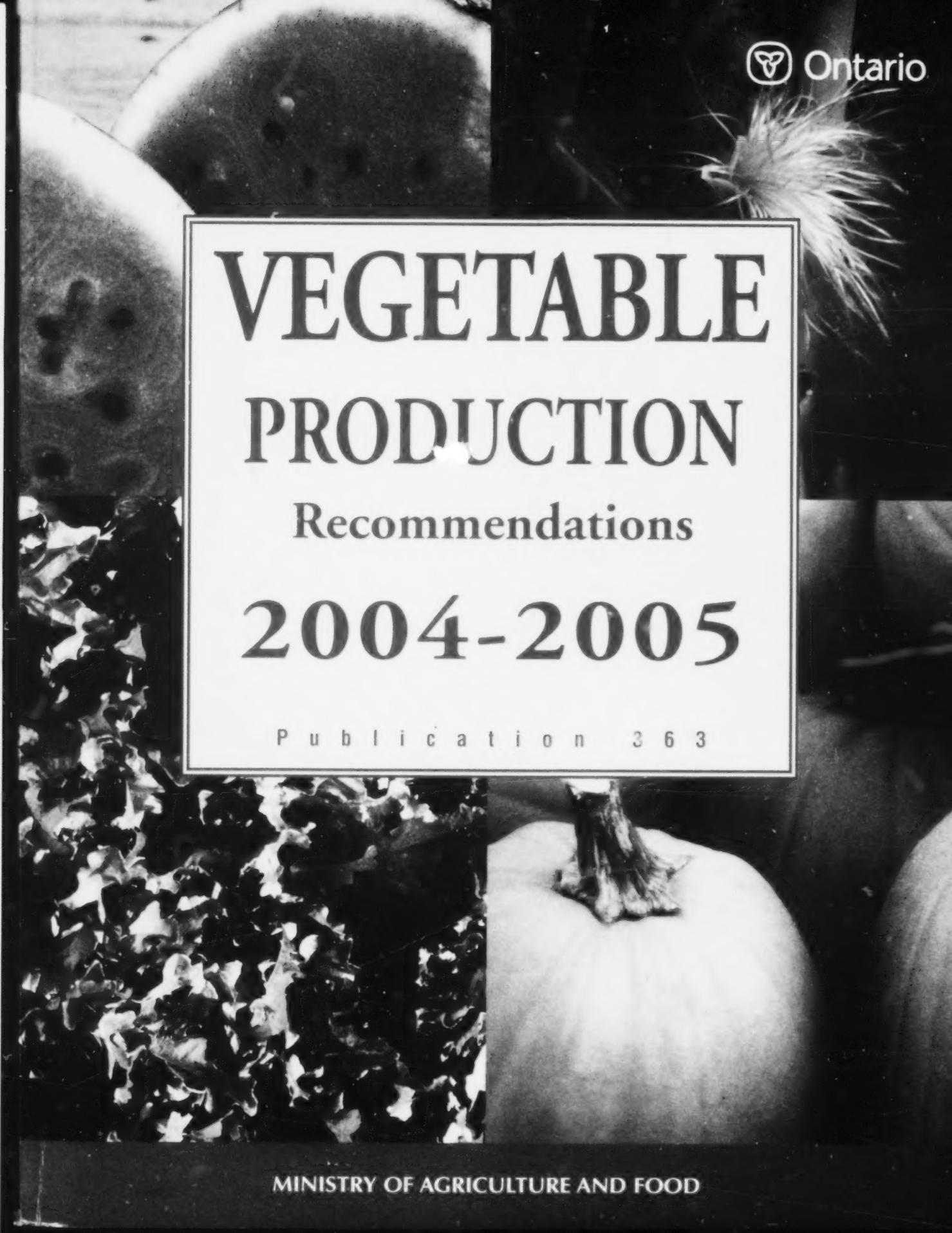


Ontario

VEGETABLE PRODUCTION Recommendations 2004-2005

Publication 363

MINISTRY OF AGRICULTURE AND FOOD

Discard old editions of this publication. Each year the appropriate sub-committee of the Ontario Pest Management Research and Services Committee reviews the pesticide products listed in this publication. To the best knowledge of the committee, at the time of printing, the pesticide products listed in this publication were:

- federally registered
- classified by the Ministry of the Environment as of November 2003.

The information in this publication is general information only. The Ministry of Agriculture and Food does not offer any warranty or guarantee, nor does it assume any liability for any crop loss, animal loss, health, safety or environmental hazard caused by the use of a pesticide mentioned in this publication.

This publication lists a number of brand names of pesticides. It is neither an endorsement of the product nor a suggestion that similar products are ineffective.

The Pesticide Label

Consult each product label before you use a pesticide. The label provides specific information on how to use the product safely, hazards, restrictions on use, compatibility with other products, the effect of environmental conditions, etc.

The pesticide product label is a legal document. It is against the law to use the product in any other way.

Federal Registration of Pesticide Products

The Pest Management Regulatory Agency (PMRA) of Health Canada registers pesticide products for use in Canada based on an evaluation of scientific data to ensure that the product has merit and value; and the human health and environmental risks associated with its proposed use are acceptable.

1. Full Registration

Pesticide registrations are normally granted for a period of five years, subject to renewal.

2. Temporary Registration

Temporary registration may be granted for a period not to exceed one year, where the registrant agrees to produce additional scientific or technical information, or the pesticide is used for emergency control of a serious pest outbreak.

Maximum Residue Limits

Health Canada has established maximum residue limits (MRLs) for pesticides. Processors or retailers may demand more restrictive limits. Growers should seek advice of their intended market to determine if more restrictive limitations apply. Keep accurate and up-to-date records on pesticide use in each crop.

Supplemental Labels

You MUST obtain a supplemental label and follow all the label directions when PMRA approves new uses for a registered pesticide that do not appear on the current label.

Examples of when you must use a supplemental label include:

- **Temporary Registrations for Emergency Use**
- **Minor Use Label Expansion**

You can obtain a copy of a supplemental label from the pesticide manufacturer or pesticide vendor, the grower association that sponsored the emergency registration or minor use, from OMAF or PMRA's Pest Management Information Service.

For more information on the federal registration status check the PMRA Web site at *www.hc-sc.gc.ca/pmra-arla* or call 1-800-267-6315.

Regulation of Pesticides in Ontario

The Ministry of the Environment is responsible for regulating pesticide sale, use, transportation, storage and disposal in Ontario. Ontario regulates pesticides by placing appropriate education, licensing and/or permit requirements on their use, under the *Pesticides Act* and Regulation 914.

All pesticides must be used in accordance with requirements under the *Pesticides Act* and Regulation 914. The *Act* and Regulation are available on the e-laws Web site at *www.e-laws.gov.on.ca* or call Publications Ontario Toll-Free number: 1-800-668-9938 or 416-326-5300.

Classification of Pesticides

The Ontario Pesticides Advisory Committee (OPAC) is responsible for reviewing and recommending to the Ministry of the Environment, the placement of pesticide products into one of six schedules used to control sale and use. Once approved by the Ministry of the Environment, classified products are posted on the OPAC Web site: *www.opac.gov.on.ca*. For more information call OPAC at (416) 314-9230.

Certification and Licensing

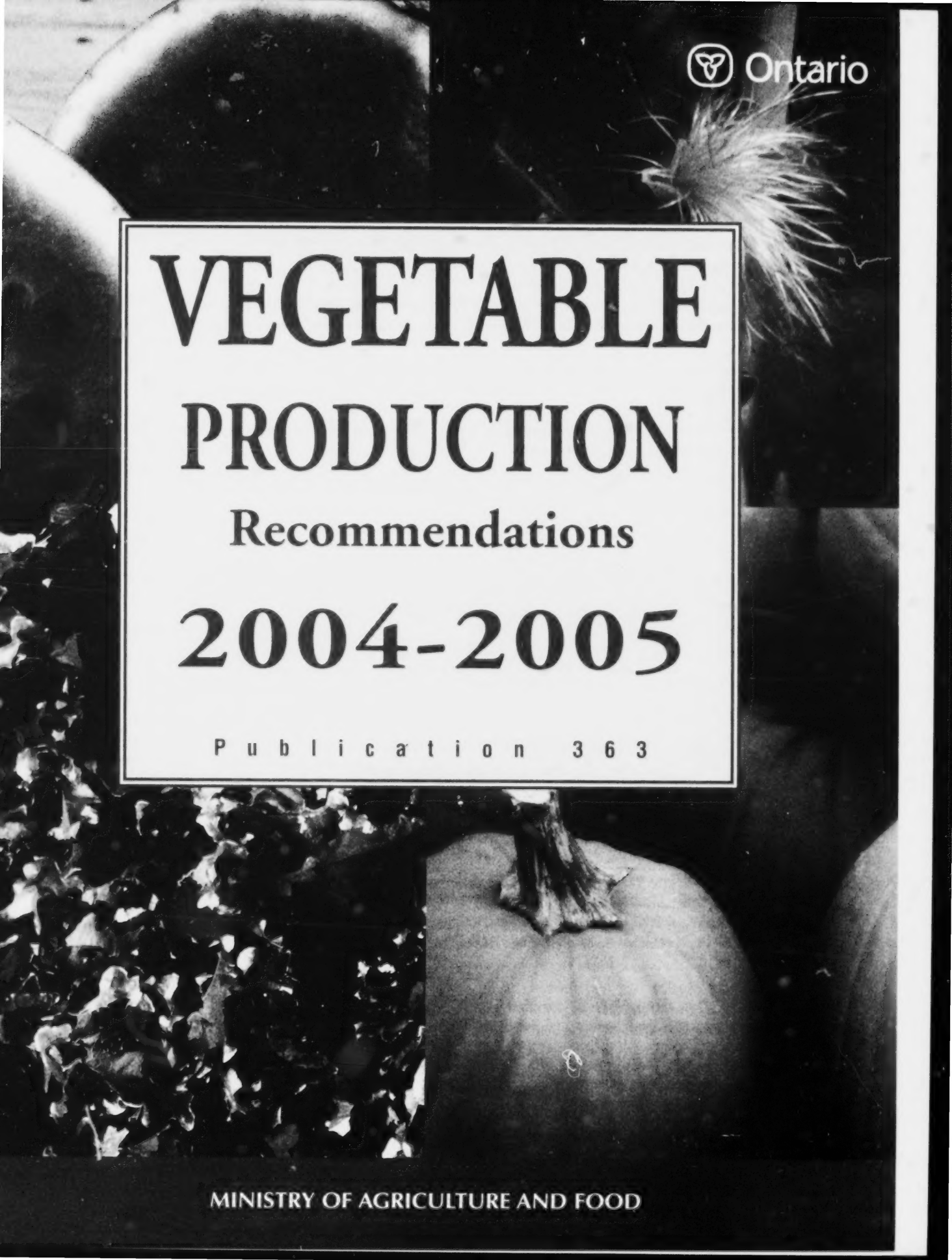
Growers and their Assistants

For information about certification for growers and training for assistants check the Ontario Pesticide Education Program Web site: *www.ridgetownc.uoguelph.ca/opep/* or call 1-800-652-8573.

Commercial Applicators and their Assistants

For information about exterminator certification and licensing and technician training check the Ontario Pesticide Training & Certification Web site *www.ridgetownc.uoguelph.ca/optc* or call 1-888-620-9999.

Cette publication est aussi disponible en français.



Ontario

VEGETABLE PRODUCTION Recommendations 2004-2005

Publication 363

MINISTRY OF AGRICULTURE AND FOOD

Be Aware of Ontario's *Nutrient Management Act* and Other Legislation

The provincial *Nutrient Management Act* (NMA) regulates the storage, handling and application of nutrients that could be applied to agricultural crop land. The objective is to protect Ontario's surface and groundwater resources.

Please consult the regulation and protocols for the specific legal details. This publication is not meant to provide legal advice. Consult your lawyer if you have questions about legal obligations.

For more information on the NMA, call the Nutrient Management Information Line at 1-866-242-4460, E-mail: nman@omaf.gov.on.ca or visit the Web site: www.omaf.gov.on.ca.

Publications and Factsheets are continually being updated, so please ensure that you have the most recent version.

Need technical or business information?

Contact the Agricultural Information Contact Centre at:

1-877-424-1300 or ag.info@omaf.gov.on.ca

Looking for vegetable production recommendations on the Internet?

www.omaf.gov.on.ca

It's one-stop shopping for factsheets, articles and photos regarding the production and management of Ontario's vegetable crops.

Acknowledgements

The recommendations in this publication have been prepared in consultation with:

- Ontario Pest Management Research & Services Committee
- Ontario Horticultural Research & Services Committee
- Ontario Soil Management Research & Services Committee
- Ontario Weed Committee

and personnel of:

- Crop Technology, OMAF
- University of Guelph
- Ontario Ministry of Environment and Energy
- Agriculture and Agri-Food Canada

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1. Precautions With Pesticides

When you decide to use a pesticide, choose the best formulations and application methods for the situation. Take all possible precautions to prevent the exposure of people and non-target organisms to the pesticide. To limit the negative impacts of pesticides:

- Select the least-toxic pesticide that will do the job. The pesticide recommendation tables included in the commodity sections of Chapter 6, *Crop Management Recommendations*, on page 61, rank registered products based on efficacy, user toxicity and environmental impact.
- Use application methods that minimize pesticide drift or spread in the environment.
- Use only a properly calibrated sprayer. (See the section *Field Boom-Type Sprayer Calibration*, on page 43.)
- Use spot treatments to limit treatments to only the plants or fields where pests are a problem.
- Take precautions to prevent exposure of humans and non-target organisms to pesticides.

Pesticide Regulations

You must report all major spills, fires or thefts involving pesticides to the Ontario Ministry of the Environment at 1-800-268-6060. (Regulation 914, s.29)

Pesticide Schedules in Ontario

The Ontario Pesticide Advisory Committee is responsible for reviewing and recommending the placement of pesticide products into one of six schedules used to control the sale and use of the pesticides. (See Table 1–1, *Pesticide Schedules*, right.)

Certification and Training Requirements

You must be a certified grower or a licensed exterminator to buy and use Schedule 1, 2 or 5 pesticides. Assistants may also use these pesticides if they are trained and supervised as required.

Table 1–1.
Pesticide Schedules

Schedule	Who Can Use It	Pesticide Characteristics
1	• licensed exterminator • certified grower • only with approved permit	very toxic very persistent highly mobile
2	• licensed exterminator • certified grower • trainee or technician under supervision (some restrictions apply) • assistant agriculturist under supervision	toxic persistent moderately mobile
3	• licensed exterminator • certified grower • trainee or technician • consumer	moderately toxic moderately persistent slightly mobile
4	• licensed exterminator • certified grower • trainee or technician • consumer	low toxicity non-persistent non-mobile containers < 1kg < 1L
5	• licensed exterminator • certified grower • assistant agriculturist under supervision	very toxic very persistent highly mobile less toxic or less persistent alternative not available
6	• licensed exterminator • certified grower • trainee or technician • consumer	low toxicity non-persistent non-mobile containers > 1 kg > l L

Pesticide Certification for Ontario Farmers

Regulation 914 of the *Pesticides Act* requires that agriculturalists (growers) be certified to buy and use Schedule 1, 2 or 5 pesticides on land they farm. To become certified, agriculturalists must:

- attend the Grower Pesticide Safety Course (GPSC) and successfully complete the examination, and
- meet the definition of an "agriculturalist" as defined by Regulation 914 under the *Pesticides Act* (i.e., use farmland for agricultural or forestry production that falls within the farmlands property class under section 7 of the *Ontario Assessments Act*), and
- be at least 16 years of age

Training for Agricultural Assistants Using Schedule 2 or 5 Pesticides

All assistants must have formal pesticide safety training, recognized by the Ministry of the Environment, before they can handle or use Schedule 2 or 5 pesticides under the supervision of a certified grower.

- This applies to all assistants, including family members, farm employees and seasonal workers.
- Trained assistants do not have to write an exam.
- Trained assistants must be 16 years of age or older.
- There are two training options for assistants. Assistants can:
  - attend a Grower Pesticide Safety Course and not write the certification examination, or
  - attend an on-farm training session presented by a qualified trained assistant instructor

To register for a Grower Pesticide Safety Course anywhere in Ontario, or for more information on training and certification requirements:

- call: 1-800-652-8573
- fax: (519) 674-1589
- e-mail: opep@ridgetownc.uoguelph.ca
- or visit the Ontario Pesticide Education Program Web site at www.ridgetownc.uoguelph.ca/opep/

Certification and Licensing for Commercial Applicators and Exterminators

If you plan to apply pesticides as a business, you must be a licensed exterminator.

This includes farmers who custom-apply pesticides for other farmers and charge a fee for this service. Licensed exterminators who are self-employed must hold an operator licence as well as the appropriate exterminator licence. Exterminator licences are valid for five years.

To become a licensed exterminator, you must:

- complete a home study course and certification exam through Ridgetown College, University of Guelph, **and**
- send proof of certification (letter of successful completion of the exam(s)) and a fee to the Ministry of the Environment to obtain your exterminator licence

Training for Technicians Working as Assistants to Licensed Exterminators

Assistants to licensed exterminators must become technicians to mix, load or apply all Schedule 3, 4 and 6 pesticides and most Schedule 2 pesticides (some restrictions apply), under the indirect supervision of a licensed exterminator. Technicians cannot mix, load or apply Schedule 1 or 5 pesticides. Technician cards are valid for 2 years.

To become a technician, you must:

- complete an MOE–approved academic course and exam, **and**
- complete practical training with a licensed exterminator

For updates to training requirements under Regulation 914 of the *Pesticides Act*, refer to the Ministry of Environment Web site at www.ene.gov.on.ca or phone 1-888-565-4923.

General Precautions

Always read the label first!

- before you buy a pesticide
- before you begin to use a pesticide
- before you store a pesticide or dispose of it

Learn about the health hazards and toxic properties of the pesticide you are using. Consult the product label, Material Safety Data Sheet (MSDS) or manufacturer for this information. Check the company Web sites for MSDS information (see Appendix B, *Pest Control Product Companies*, on page 188.)

Protect Yourself When You Use Pesticides

- **Make sure someone knows** where you are working, what pesticides you are handling and how long you expect the job to take.
- **Post emergency numbers**, including the Poison Information Centre and Spills Action Centre, near all of your telephones.
- **Keep a list of the names and the *Pest Control Products (PCP) Act* registration numbers** of all the pesticides you handle. Keep a file of the pesticide label booklets for all the products you use. Make sure that your co-workers and family members know where this list or file is in case of an accident.
- **Have plenty of clean water, soap and paper towels — and an extra set of gloves and coveralls — nearby at all times**, in case pesticide contaminates your clothing or skin.

Read and Follow Pesticide Label Information

Know the Hazard Symbols and Words

Learn these symbols and words. They could save your life.

Four important symbols and words show the potential hazards of pesticides.

Hazard Symbol				
Signal Word	Poison	Corrosive	Flammable	Explosive

The hazard symbol will always appear inside one of the shapes shown below. These shapes and their warning words tell you the degree of hazard of the pesticide. The greater the number of sides to the shape, the more hazardous the product.

Warning Symbol			
	Triangle = low hazard (3 sides)	Diamond = moderate hazard (4 sides)	Octagon = high hazard (8 sides)
Signal Word	Caution	Warning	Danger

Check the label for special warnings about eye hazards and skin hazards. The front panel of the pesticide label may also contain warnings that tell you the product is corrosive to eyes, or is a skin or eye irritant.

- **Wear the correct protective clothing and equipment, and be sure that all items are clean and in good repair** before you put them on.
- **Never smoke, chew tobacco, eat or drink when you handle pesticides.** Never carry tobacco or food in your clothes —and never leave tobacco, food or beverages in areas where you handle or store pesticides.
- **Change your clothes and wash your hands and face before you eat, drink or smoke.**
- **Wash your hands before you use the toilet, as well as after.** The skin in your groin area absorbs pesticides very easily.

Human Health

Each time you handle a pesticide, you are at some risk. The amount of risk depends on two things — the toxicity of that pesticide and your exposure to it.

Risk = Toxicity x Exposure

Toxicity

Toxicity is a measure of how harmful or poisonous the pesticide is. There are 2 types of toxicity — acute and chronic.

Acute toxicity

Acute toxicity is the toxic response that results from a **single exposure** to the pesticide. The symbols and words on the front panel of a pesticide label give you information about the acute toxicity.

Examples of products listed in this publication with a high acute toxicity include:

Common Name	Trade Name
azinphos-methyl	Guthion, APM, Sniper
carbofuran	Furadan
endosulfan	Thiodan, Thionex
methamidiphos	Monitor
methomyl	Lannate
oxamyl	Vydate
phorate	Thimet
terbufos	Counter

Lethal dose 50% (LD_{50}) is a measure of acute toxicity. It is the dose (mg of product per kg of body weight) that will kill 50% of the test animals within a stated period of time (24 hours to 7 days). Those products with low LD_{50} ratings are highly toxic.

Chronic toxicity

Chronic toxicity results from repeated exposures to small doses of a pesticide over a longer period of time. These toxic effects may not appear for months or years after exposure to the pesticide. The symbols on the label do NOT give information about the chronic toxicity of the product. Use protective clothing and equipment to help reduce exposure and the risk of chronic effects.

Exposure

Exposure is a measure of the contact you have with the pesticide. You can be exposed to the pesticide in three ways.

1. Dermal exposure occurs through your skin or eyes. The amount and rate of pesticide that may be absorbed depends on several things, including:
   - your skin condition. If your skin is moist, or if you have rashes, broken skin or scratches, pesticide will be absorbed more easily.
   - the part of your body that is exposed. Your eyes, genital area, scalp and ear canals absorb pesticides at a higher rate than your hands or arms. Your eyes absorb pesticides at a rate of 100%.
2. Respiratory exposure (inhalation) occurs when you inhale small spray particles, dust, gases or vapours.
3. Oral exposure occurs when a pesticide enters your mouth or you swallow a pesticide.

Cholinesterase Blood Tests

Organophosphorus and *carbamate* pesticides can affect your nervous system. These pesticides can change your serum and red blood cell levels of an enzyme called acetyl cholinesterase. Your body uses this enzyme to transmit messages through your nervous system. If your cholinesterase levels fall, you can experience symptoms, including trembling, twitching, blurred vision, difficulty breathing and heart difficulties.

If you use any of the pesticides listed in Table 1–3, *Relative Toxicity of Insecticides to Honeybees*, on page 8, on a regular basis, you should have regular cholinesterase blood tests. Your family doctor can arrange these tests, and they are covered by OHIP.

Have your first test during the off-season, before you begin to handle these pesticides. That will show the baseline (normal) cholinesterase level for your body. During the spray season, if you are spraying organophosphorus or carbamate insecticides regularly for several weeks, you should have a cholinesterase blood test regularly.

If your cholinesterase level drops to below one-half of your baseline level, then you are showing signs of pesticide poisoning and **you must remove yourself from exposure** to these pesticides until your cholinesterase level returns to normal.

Personal Hygiene

Always wash your hands before you eat, drink or smoke.

When you are finished for the day, take a bath or shower as soon as possible. The longer a pesticide remains on your skin, the greater the risk that it will be absorbed into your body.

Wash your hair and under your fingernails. Shower with lots of soap and water.

Always change into clean clothes.

Wear clean work clothes every day. A small spill on the previous day's clothes may seem unimportant, but wearing the same clothing again without washing it prolongs the exposure and increases your risk.

First Aid

Always protect yourself from injury first. Don't become another victim. Always put on protective clothing and equipment before you enter a contaminated area or handle a contaminated victim.

Protective Clothing and Equipment

Make sure your protective clothing and equipment:

- are what you need for the job
- fit properly, and
- are clean and in good repair and working condition

The protective clothing and equipment you will need depends on:

- the pesticide you are using — Read the precautions section of the label to know what to wear.
- the job you are doing — For example, you need more protection when you handle concentrated pesticide or when you mix and load your sprayer.
- the type of application — For example, enclosed space or air blast sprayer applications made with open tractors require more equipment.

Each person who is working with pesticides needs **his or her own** set of protective clothing and equipment. Consult the technical expert at your safety supply company to make sure that you purchase the appropriate equipment and that it fits the user. See Table 1–2, *Safety Supply*

Table 1–2.
Safety Supply Companies in Ontario Providing Protective Clothing and Equipment

3-M Canada Company	Occupational Health and Environmental Safety Box 5757 London, ON N6A 4T1	(519) 452-6165 1-800-364-3577 Fax: (519) 452-4660
Acklands Grainger	90 W. Beaver Creek Rd. Richmond Hill, ON L4B 1E7	(905) 731-5516 1-800-668-8989 Fax: (905) 731-2798
Aearo Canada	6889 Rexwood Rd. Mississauga, ON L4V 1R2	(905) 795-0700 1-800-387-4304 Fax: (905) 564-5250
Dutch Industries "Protect-Air Cab Filter"	Huron Tractor, Box 1300 Exeter, ON N0M 1S3	(519) 235-1115 Fax: (519) 235-1939
HAMISCO	3392 Wonderland Rd. London, ON N6L 1A8	(519) 652-9800 1-800-668-9800 Fax: (519) 652-9661
Dupont Personal Protection	20 Ryan Place Brantford, ON N3S 7S1	(519) 752-4369 1-800-387-9326 Fax: (519)752-2161
Levitt-Safety (Eastern) Limited	2872 Bristol Circle Oakville, ON L6H 5T5	(905) 829-3299 1-800-668-6153 Fax: (905) 829-2919
MSA Canada	2800 Skymark Ave., Unit 33 Mississauga, ON L4W 5A6	(905) 602-0338 1-800-267-0672 Fax: (905) 238-4151
Mitt & Robe Co. Ltd.	751 Norfolk St. N. Simcoe, ON N3Y 3R6	(519) 428-4050 1-877-893-6565 Fax: (519) 428-5142
Plant Products Co. Ltd.	314 Orenda Rd. Brampton, ON L6T 1G1	(905) 793-7000 1-800-387-2449 Fax: (905) 793-9632
Safety Express	4060B Sladeview Cres. Unit 2 Mississauga, ON L5L 5Y5	(905) 608-0111 1-800-465-3898 Fax: (905) 608-0091
The St. George Company (Suppliers of Kasco Helmets)	P.O. Box 430 20 Consolidated Dr. Paris, ON N3L 3T5	(519) 442-2046 1-800-461-4299 Fax: (519) 442-7191

Companies in Ontario Providing Protective Clothing and Equipment, above, for a list of supply companies.

Clothing

For ALL pesticide applications always wear:

- a water-repellent hat, such as a hard hat or waterproof rain hat. Do not wear hats made from cloth; they absorb pesticides and are not safe.
- long pants and a shirt with long sleeves or a coverall
  - Coveralls can be reusable or disposable. Reusable coveralls are normally cotton or polyester and should be tightly woven. Disposable coveralls should be designated for pesticide use.
  - Water-resistent coveralls are preferred because cotton, denim and cotton/polyester pants cling to the skin if they get wet, increasing the risk of dermal exposure.
- chemical-resistant gloves (unlined)
  - Use neoprene or nitrile gloves (PVC), unless the label states otherwise. Do not wear rubber gloves, as many pesticides can break down the rubber material. Wear your gloves under your sleeves with the top cuffed.
- chemical-resistant boots (unlined)
  - Wear your pant legs over your boots to prevent pesticide from running down inside your boots.

Read the label. It will describe what extra protective clothing and equipment to wear. For some pesticides you may also need to wear:

- goggles
  - Use safety goggles with indirect vents so that splashes do not enter your eye. Regular eyeglasses don't provide complete protection. **Never wear contact lenses when you handle pesticides.**
- face shield
- chemical-resistant apron
- respirator
  - A respirator is a unit that covers your mouth and nose to prevent spray droplets, small particles and vapours

from getting into your lungs. **A dust mask is not a substitute for a pesticide respirator.** Make sure you use cartridges and pre-filters that protect you against organic vapours. For more information about respirators, see the *Grower Pesticide Safety Course Manual,* Ridgetown College, University of Guelph.

- You may need more protection, such as canister gas masks or a self-contained breathing apparatus (SCBA) when you apply:
  - any pesticide in an enclosed area
  - fumigants, gases, vapours or smokes

When you work with fumigants, gases or vapours or when you apply any pesticide in an enclosed area, ALWAYS wear a respirator.

Care of Protective Clothing

After you complete the spray operation, clean all protective clothing and equipment. Always remove protective clothing and equipment outdoors. If you were using a granular pesticide, shake the clothing outdoors in a safe place, emptying pockets and cuffs.

Wash coveralls and other spray clothing separately from other clothes. Throw out clothing that has been contaminated by spills of highly toxic or concentrated pesticides.

Never let children, pets or livestock come in contact with contaminated clothing or equipment. Also make sure that they cannot come into contact with the puddles of water left over from cleaning your equipment.

For more information on the care and cleaning of protective clothing, see the *Grower Pesticide Safety Course Manual,* Ridgetown College, University of Guelph.

Use Organic Vapour Tractor Cab Cartridges

If you use a tractor with a cab when you spray, use tractor cab cartridges, which work the same way as an air-purifying respirator. These cartridges and pre-filters must be replaced and maintained on a regular basis to provide continued protection.

Safety Supply Companies

Consult the safety supply companies of your choice for help in selecting your protective clothing and equipment. (See Table 1–2, *Safety Supply Companies in Ontario Providing Protective Clothing and Equipment*, on page 5.)

Pesticides and the Environment

Prevent Contamination of Adjacent Land and Water Bodies

Do not allow pesticides to drift, run off or leach onto land or water bodies bordering treatment areas. Leave a suitable buffer zone between the treatment area and adjacent areas. No spray droplets should fall on adjacent properties, where treatments are not authorized. Areas of concern are:

- cultivated plants grown for human consumption
- plants sensitive to herbicide drift
- trees or shrubs that may be damaged by herbicides leaching to roots
- areas where children play

Buffer Zones

Buffer zones are vegetated areas, left untreated to protect an adjacent area, for example a pond, a stream, a sensitive crop, a non-target crop, wetland or woodland, etc.

Setback Distances for Water Bodies

It is an offence under the federal *Fisheries Act* to introduce any material into water that may be harmful to fish or fish habitat. To protect these waters, landscape applicators must determine a suitable setback distance between the area to be protected and the area where pesticide treatments are planned. The protected area includes the water body, as well as adjacent riparian (riverbank) areas that contribute to fish food and habitat.

Protect Water Sources

- Use an anti-backflow device to prevent back-siphoning when drawing water from wells, ponds, streams or other sources.
- Mix pesticide and load the sprayer away from any water supply, including wells, ponds or streams.
- Use buffer zones (untreated areas) when you apply pesticides to avoid contaminating surface water, wells, ponds and/or streams, especially those containing fish. Check the product label for specific buffer zone recommendations. See the section *Setback Distances for Water Bodies*, above.
- Do not allow equipment rinse water and excess pesticides to run into sewers, drains or ditches with water in them. Rinse water should be put into spray tanks and applied to the treatment area. Otherwise, it must be disposed of as hazardous waste through a hazardous waste disposal company. For more information, see the section *Disposal of Pesticides and Empty Pesticide Containers*, on page 8.

Preventing Groundwater Contamination

Groundwater is the source of water for wells and springs. If groundwater becomes contaminated with pesticides, it is difficult to clean. Preventing groundwater contamination is crucial. Some pesticides have the potential to leach through the soil to groundwater. Movement of pesticides into groundwater can make the water unfit for use.

However, pesticides applied to the soil are subjected to physical, chemical and biological processes that affect their movement through the soil and their potential for groundwater contamination. Making the right pesticide choices for the situation can help minimize the threat of groundwater contamination.

Soil Characteristics

Soil texture plays a major role in pesticide performance and persistence. Soil organic matter can make a difference in pesticide activity. Therefore, it is important to select a pesticide based on soil type and organic matter content. Chemicals tend to leach more readily in coarse-textured soils with low organic-matter content. In contrast, fine-textured soils with high organic matter are highly adsorptive and therefore have a low leaching potential.

Pesticide Characteristics

Some pesticides bind strongly (adsorb) to soils and therefore are not easily removed. Clay materials and organic matter favour strong adsorption. Use soil analysis information on organic matter content when selecting pesticides and application rates for your pest management program. Some pesticides are highly soluble in water, which can increase their leaching potential. Leaching of a pesticide can be minimized by pesticide dosage and by the timing and method of application. Choose the right pesticide for your situation.

The rate of degradation by natural processes is highly dependent on both the pesticide class (chemistry) and environmental factors. Sunlight, temperature, soil, pH, microbial activity and other soil characteristics affect the breakdown of pesticide. Some pesticides break down slowly and therefore have a greater potential for leaching. A short-lived pesticide may be degraded before any leaching occurs. Choosing a short-lived pesticide can minimize leaching potential.

Microbial degradation occurs when fungi, bacteria and other soil microorganisms use pesticides as a food (energy) source. High organic matter, along with other properties such as optimum moisture, aeration, temperature and soil pH, can enhance microbial degradation. In addition, chemical degradation of pesticides can occur by reaction with water, oxygen and other chemicals. In general, pesticides that are highly water-soluble, relatively persistent and not readily adsorbed by soil have the greatest potential for leaching.

Water Table

High water tables may be vulnerable to contamination by pesticides and fertilizers due to the relatively short distance between the soil surface and groundwater. There is potential for groundwater contamination in areas with coarse-textured soils and high water tables.

Specific application information for each pesticide is contained on the pesticide label. Careful adherence to application and disposal directions, combined with proper equipment calibration, provide the best method of preventing groundwater contamination.

Reduce Pesticide Spray Drift

- Read the product label for information regarding buffer zones, water volumes and recommended nozzles.
- Use buffer zones around all watercourses and wells as well as neighbouring fields that contain sensitive crops. If the label does not state a specific buffer zone distance, leave an untreated area of natural vegetation.
- Select the recommended sprayer application rate (L/ha).
- Select the correct nozzle. Where practical, use air induction/venturi nozzles. These nozzles significantly reduce drift compared to conventional nozzles.
- Select the correct nozzle-to-target distance.
- Spray only when winds are light to moderate (11 km/hr or less). If you notice drift is occurring because of the wind, **stop spraying** until the wind subsides. Do not apply pesticides if the wind is blowing towards susceptible crops or environmentally sensitive areas such as watercourses.
- Use spray plume protection where practical or available (hoods, shrouds, screens and air curtains).
- Use drift-reducing adjuvants in the spray tank as directed by the label.
- Utilize wick weeders, instead of spraying, when possible.
- Use non-volatile compounds.

For more information about spray drift, see:

- *Best Management Practices — Pesticide Storage, Handling and Application* (OMAF/Agriculture and Agri-Food Canada booklet)
- *How to Manage Spray Drift* (Ontario Pesticide Education Program (Ridgetown College) video)
- *Spray Drift Reduction Through Air Induction* (Ontario Pesticide Education Program (Ridgetown College) video)

Table 1–3.
Relative Toxicity of Insecticides to Honeybees

Trade Name	Common Name
Group 1. Very toxic. Do not apply to flowering crops or weeds.	
Diazinon, DZN	diazinon
Cygon, Lagon	dimethoate
Furadan	carbofuron
Guthion, Sniper, AMP	azinphos-methyl
Imidan	phosmet
Lannate	methomyl
Lorsban, Pyrifos, Pyrinex	chlorpyrifos
Malathion	malathion
Monitor	methamidophos
Pounce	permethrin
Ripcord, Cymbush	cypermethrin
Sevin	carbaryl
Group 2. Apply only during late evenings or early morning.[1]	
Decis	deltamethrin
Endosulfan,Thiodan, Thionex	endosulfan
Pirimor	pirimicarb

[1] Unusually low temperatures at time of application may cause insecticides to remain toxic up to 20 times longer than during warm weather. High temperatures in the early morning or late evening may extend active foraging by bees.

Prevent Bee Poisoning

It is important to protect bees when you spray. Honeybees, as well as other bees and insects, are important pollinators of crops. Many crops also offer bees important sources of pollen for honey production.

If you choose to use insecticides for insect control, take these steps to prevent harming bees when you spray:

- Before you apply a pesticide, advise local beekeepers, so that they can move colonies out of the danger area. Contact the Provincial Apiarist at 1-888-466-2372 for a list of the beekeepers in your area.
- Do not spray any flowering crop on which bees are foraging. If you must apply insecticides, spray after 7 PM when the bees are not foraging. If this is not a possibility, spray before 7 AM. Bees usually do not forage at temperatures below 13°C (55°F).
- Do not apply insecticide on windy days to prevent drift toward any nearby hives.
- When there is a choice, choose the product formulation that is less hazardous to bees. **Dusts are more toxic than sprays. WP formulations are more toxic than EC formulations.**
- Under the *Bees Act*, it is an offence to spray in orchards while there is bloom on the trees.

Most organophosphate and carbamate insecticides are highly toxic to bees. Examples of insecticides used in crop production that are very toxic to bees are listed in Table 1–3, *Relative Toxicity of Insecticides to Honeybees*, left.

Read each pesticide label for specific precautions regarding bees.

Disposal of Pesticides and Empty Pesticide Containers

Rinsing

Unrinsed pesticide containers are not really empty. They may still hold about 1% of the original amount of pesticide. Although this figure sounds low, it is still a hazard to humans, animals and the environment. To reduce the hazard, rinse each container 3 times as the spray tank is filling. Use either the manual triple rinse technique or a specially designed device for rinsing containers. Paper or cardboard containers are often strong enough to be rinsed. If it is possible, rinse these containers as well as plastic ones.

For more information on rinsing, refer to OMAF Factsheet No. 87-057, *Pesticide Container Rinsing.*

Triple Rinse

To triple rinse:

1. Fill the empty container at least 10% full of the diluting material (usually water).
2. Cap, then shake or roll the container so that the inside surfaces of the container are well rinsed.
3. Pour rinsings into the spray tank.
4. Repeat steps 1–3 twice more.

Remember to check the container after you have finished rinsing. Make sure that no pesticide has been left behind as a cake or paste on the bottom of the container.

Rinsing Devices

Rinsing devices use pressurized water to clean out the container. They are just as effective as triple rinsing but take less time. Follow the manufacturer's instructions.

Disposal

Never re-use empty pesticide containers. They may be handy, but there is still some risk, even if the containers are triple rinsed. Never give empty, rinsed containers to

anyone, especially not children. Dispose of them promptly.

Regulation 914 of the *Pesticides Act* regulates how pesticide containers are to be disposed of in Ontario (Reg 914, s.27).

Metal, Plastic or Glass Containers

An empty metal, plastic or glass container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide shall be disposed of by:

- triple rinsing or jet rinsing using clean water, or another appropriate solvent

AND either

- taking it for recycling to a Pesticide Container Depot

OR

- taking it to a licensed waste disposal site

Once containers are properly rinsed, they should be punctured to make it impossible to use them again and to make sure the rinse water is out of the container.

It is often more convenient to store empty, rinsed containers until you have collected enough to make a trip to the recycling Pesticide Container Depot or the waste disposal site. If you store containers, keep them in a dry safe place, such as the pesticide storage area, until you can dispose of them properly.

Recycling

The Ontario Pesticide Container Recycling Program is available to growers and commercial exterminators. Through this program, **clean, triple-rinsed, plastic and metal pesticide containers** (up to 23 L in size for plastic and 20 L in size for metal) can be returned to Pesticide Container Depots located throughout the province.

To locate the Pesticide Container Recycling Depot closest to you, call the Ontario Pesticide Education Program at 1-800-652-8573.

Paper and Cardboard Containers

A paper or cardboard container that has been used to hold a Schedule 1, 2, 3*, 5 or 6* (*non-domestic) pesticide shall be disposed of by:

- triple rinsing or jet rinsing (if possible) using clean water;

AND either

- burning (if allowed by municipal bylaws), in circumstances that persons and animals are kept out of any smoke produced and any smoke is directed away from buildings, highways, roads or outdoor areas frequented by the public

OR

- taking it to a licensed waste disposal site

Paper or cardboard containers are often rigid enough to withstand rinsing. If it is possible, triple rinse these containers as you fill the tank. Then burn the containers in an isolated area on your farmland.

Be very careful around the smoke. It may contain toxic fumes from the burning pesticide. Be certain that there is no chance that a person or animal may breathe in this smoke. Make sure that the smoke does not drift toward buildings, roads or any public outdoor areas.

These containers can also be taken to a local waste disposal site as for metal, plastic or glass containers. If you can't dispose of them immediately, make sure containers are kept in a secure place such as the pesticide storage area.

Unwanted Pesticides

If you have pesticides that you do not need or cannot use, be sure to dispose of them safely.

- Contact the supplier. It is sometimes possible to return unused pesticide if it is still in its original container.
- If you cannot find any way to use the product as shown on the label, then the Ministry of the Environment requires that waste be disposed of by licensed waste haulers to a licensed waste disposal site. Look in the Yellow Pages of your telephone directory under "Liquid Waste Removal."
- Watch your local paper for Municipal Hazardous Waste Collection Days or contact your municipality. If your municipality has no waste collection days, encourage it to sponsor such an event. On these days, you can turn over surplus pesticide concentrates (maximum 25 L) for disposal.

Surplus Spray Mix

The best way to dispose of any excess spray mix is to find other fields that require an application of this pesticide. Before spraying, check the label to make sure the pesticide is registered for use on that crop.

If you can't find another field to spray, then dilute the remaining spray mix by adding 10 parts of water for each 1 part of spray mix. This diluted solution can be safely applied to the treated area as long as you do not exceed the pesticide rate recommended on the label. Be sure to check the label for any restrictions about crop rotation, days to harvest or surplus spray mix disposal.

NEVER re-spray the treated field with undiluted spray mix. Spraying an area twice will double the recommended pesticide rate. This may cause illegal pesticide residues in the harvested produce or crop damage.

Soluble Packaging Options

Choose soluble packages that dissolve in the spray tank to reduce container disposal. Water-soluble packaging is used for dry flowable and wettable powder formulations of pesticides and is available under names such as Clean Pak, Solupak and Toss-N-Go. In most cases, the water-soluble packaging material is PVA (poly vinyl alcohol). This material dissolves completely when added to the water in the sprayer tank according to instructions.

Read all labels and instructions carefully. For more details, contact your vendor.

Keep soluble pouches dry until you add them to the spray tank:

- Do not handle pouches with wet hands or wet gloves.
- Do not remove pouches from the outer package until you are ready to add them.
- Always reseal the outer package to protect the remaining pouches from moisture.

Mixing Soluble Pouches

- Consult product labels for specific mixing instructions for each product.
- Fill the spray tank half full of water. With the agitator running, add the water-soluble pouches to the tank.
- Most pouches dissolve completely within 5 minutes, depending on the water temperature and the degree of agitation.
- As the tank continues to fill, add any other compatible pesticides.

Table 1–4.
Pesticides Act Storage Requirements

	Schedule		
	3, 4, 6	2	1, 5
'No contact with food or drink	♦	♦	♦
Does not impair health/safety	♦	♦	♦
Clean & orderly manner	♦	♦	♦
Warning signs posted on storage buildings	♦	♦	♦
Warning signs posted on unattended vehicles	♦	♦	♦
Emergency telephone numbers posted	♦	♦	♦
Ventilated to outside		♦	♦
Limited access (locked)		♦	♦
No floor drain		♦	♦
Safety equipment available		♦	♦
Area used exclusively for pesticides			♦

Do not add:

- a pesticide that is incompatible with the PVA packaging material. The PVA material is not soluble with summer-type oils (e.g., Superior Oil).
- any material containing boron (e.g., Solubor), chelated micronutrients or water-soluble fertilizers. This combination is likely to cause a sticky, insoluble substance in the tank. If you apply boron, chelated micronutrients or water-soluble fertilizers, make sure that you completely empty and rinse the spray tank before you use any product packaged in PVA.

Storing Pesticides

Ontario's *Pesticides Act* and Regulation 914 give storage requirements for storage facilities. The storage requirements that you must follow depend on which schedules of pesticides that you store. See Table 1–4, *Pesticides Act Storage Requirements*, above.

> See also the OMAF Factsheet, *Pesticide Handling Facilities*, Order No. 94-037.

Pesticide Spills

If a pesticide spill causes, or is likely to cause, an adverse effect, you must notify the Ministry of Environment Spills Action Centre at 1-800-268-6060 (24 hr a day, 7 days a week) **and** the municipality.

Protect yourself before you begin to clean up any spill. Clean up spills immediately.

In the case of minor spills:

- For liquids, cover the spill with a thick layer of absorbent material such as kitty litter, vermiculite or dry soil. Sweep or shovel the material into a waste drum.
- For powders and granulars, sweep or shovel the material into a waste drum.

In the case of a major spill:

- Remove any people or animals from the spill area.
- Stop the spill from spreading.
- Do not let the pesticide enter any watercourse.

For information on preventing spills, see the OMAF Factsheet, *Ways to Avoid Pesticide Spills*, Order No. 96-025.

Application Procedures

Aerial Application by Airplane or Helicopter

Any person who applies pesticide from an aircraft in Ontario **must** hold an aerial exterminator licence. In addition, a permit is required to purchase and apply pesticides by air for the following:

- applications to surface water, e.g., ponds, lakes, rivers (exceptions in some cases)
- applications to forests as defined in the *Crown Forest Sustainability Act*
- applications of any Schedule 1 or 5 pesticide

Be sure that any pesticide you apply by air has specific instructions for aerial use on the label.

Take extra precautions when using insecticides applied by air that are toxic to honeybees, such as Sevin (carbaryl) or Furadan (carbofuran).

Fumigants

Read and follow all instructions on the product label regarding protective clothing and equipment, aeration of treated areas and re-entry periods. When fumigating a greenhouse, lock the building and post warning signs. As a safety precaution, have someone else who is wearing personal protective equipment help with the fumigation. (This is a requirement for all fumigant gas use.)

If you use a fumigant gas such as methyl bromide plus chloropicrin or aluminum phosphide to fumigate a structure, you must hold the appropriate licence **and** obtain a permit issued under Ontario's *Pesticides Act*. To apply for a permit, contact the regional pesticides officer with the Ontario Ministry of the Environment (see Appendix C, *Ontario Ministry of the Environment Pesticides Control Offices*, on page 189, for contact information).

When you handle methyl bromide, *do not* wear gloves. Wear a self-contained positive-pressure breathing apparatus. When you handle aluminum phosphide, use cotton gloves and wear a full-face mask respirator with an acid gas canister, or a self-contained positive-pressure breathing apparatus.

For more information, refer to the Fumigation Study Module from Ontario Pesticide Training and Certification, compiled by the Ontario Ministry of the Environment.

Band Spraying

When banding pesticides, apply the recommended rate over the strip of row you wish to treat. Banding does not result in a more concentrated spray mixture. It does allow you to cover more area with the same amount used in a broadcast application. Check the product label under "Directions for Use." Some labels give specific nozzle recommendations and formulas to determine band application rates.

To know how much to mix, you will first need to calculate the size of the entire treated area. To calculate the total area of all the treated bands:

$$\text{Treated Area of Bands (ha or acres)} = \text{Total Area of Planted Field (ha or acres)} \times \frac{\text{Band Width (cm or in)}}{\text{Row Spacing (cm or in)}}$$

Seed Treatments

Treated seed products are also pesticides. They are poisonous to people and animals.

Wear protective clothing and equipment when you are treating seed or handling treated seed. Protect your skin. Wear a long-sleeved shirt, long pants or coveralls and wear neoprene or nitrile gloves. Protect your eyes with goggles and/or a face shield. Wear a respirator to protect your lungs from dusts and vapours.

Wash thoroughly after finishing the treatment or handling the treated seed. Never feed treated seed to animals. Keep treated seed out of the reach of children.

Destroy all the bags that have held treated seed as recommended in the section *Disposal of Pesticides and Empty Pesticide Containers*, on page 8.

Questions on Pesticide Use and Safety?

Contact the Ontario Pesticide Education Program

1-800-652-8573

Fax: (519) 674-1589

E-mail: opep@ridgetownc.uoguelph.ca

Web site: www.ridgetownc.uoguelph.ca/opep/

2. Soil Fertility

For a complete guide to soil fertility, consult OMAF Publication 611, *Soil Fertility Handbook*.

Ontario agriculture currently uses about 740,000 tonnes of fertilizer annually. High yields can be produced efficiently only when fertilizer use is related to the fertility level of the soil. Additions of other nutrients (manure, crop residues and other organic sources) must also be taken into consideration.

At one extreme, very low-fertility soils may require the addition of as much or more nitrogen, phosphorus or potassium in the fertilizer as a crop removes to reach maximum profitability. At the other extreme, on high fertility soils or following heavy application of manures, adding additional fertilizer may be unprofitable and may occasionally reduce yield or negatively impact crop quality.

Assessing Nutrient Needs

1. The OMAF-accredited soil test is the most accurate tool available to Ontario farmers to determine the amounts of phosphorus, potassium, magnesium and lime that should be applied for crop production. Farms that are required to complete a nutrient management plan under the *Nutrient Management Act*, Ontario Regulation 267/03 (new or large livestock farms) must use OMAF-accredited tests.
2. Plant analysis of vegetables is a tool that can potentially provide additional information supporting the soil test.
3. Leaf symptoms are helpful in evaluating some nutrient deficiencies. However, by the time deficiency symptoms are visible, yield losses may have already occurred.
4. It is occasionally suggested that a grower apply the amounts of nutrients removed by the crop. This has some application for nitrogen (for some crops, the recommended rate approximates what the plant removes) but has little relevance for other nutrients in Ontario. Some Ontario clay and clay loam soils have sufficient potassium to last many years. Applying potassium each year on those soils is a waste of money (unless potassium plays a key role in the quality of that particular crop) and ignores one of the few advantages that clay soils have over coarser-textured soils.

Table 2–1.
OMAF-Accredited Soil Tests

See Appendix D, *Accredited Soil-Testing Laboratories in Ontario*, on page 190, for a list of accredited labs in Ontario.

Materials	What is Analyzed[1]
Soils for field-grown crops, commercial turf, etc.	plant-available phosphorus, potassium, magnesium, zinc and manganese pH lime requirement
Greenhouse media	plant-available nitrogen, phosphorus, potassium, calcium, magnesium pH total salts
Nutrient solutions, water	plant-available nitrogen, phosphorus, potassium, calcium, magnesium pH total salts sulphates chlorides

[1] Soil organic matter tests can be useful for herbicide recommendations or for evaluating soil quality but are not accredited tests.

Use the OMAF-accredited soil testing program along with plant analysis and evidence from nutrient deficiency symptoms as the main guide for determining fertilizer requirements for a specific crop on a specific field. See Table 2–1, *OMAF-Accredited Soil Tests*, above.

Soil Testing

The OMAF-accredited soil testing program provides recommendations for nitrogen, phosphate, potash and magnesium fertilizer, as well as recommendations for the amount and type of lime to be applied. (See Table 2–1, above.)

The OMAF-recommended fertilizer rates are provided in this publication. They are designed to produce the highest economic yields when accompanied by good or above-average management.

Research shows that higher rates will occasionally produce higher yields. These increases in yields are likely to be small and not profitable. Some fertilizer recommendations have been set slightly higher than the most economic crop response rate. This is done to maintain soil nutrient levels and to allow for some error in sampling. In some cases, crop quality is also associated with the maintenance of high soil nutrient levels.

A soil test recommendation is affected by manure application, plowing down of legume sod and the type of crop to be fertilized. This information is essential for a reliable fertilizer recommendation and should be recorded on the field information sheet that must accompany the soil sample sent in for analysis.

Sampling

Soils may be sampled with a soil probe or with a shovel. Each field or uniform section of a field should be sampled separately. For fields up to 5 ha (12 ac) in size, take at least 20 soil cores 15 cm (6 in.) deep. Take proportionately more cores for fields larger than 5 ha (12 ac). The more cores taken, the more likely the soil sample is to provide a reliable measure of the fertility in the field. One sample should not represent more than 10 ha (25 ac).

Travel the area sampled in a zigzag pattern to provide a uniform distribution of sampling sites. Take a separate sample for any parts of a field that differ in appearance of soil or crop, in previous fertilization, manuring or liming, even if they are too small to fertilize separately. Avoid sampling recent fertilizer bands, dead furrows, areas adjacent to gravel roads or areas where lime, manure, compost or crop residues have been piled.

Collect the soil in a clean plastic pail. Break the lumps and mix the soil well before sending a soil sample for testing.

When to Sample

Sample each field once every 2 or 3 years. Farms that must complete a nutrient management plan (NMP) must collect soil samples at least once from each field for every NMP renewal. Potash levels can change quickly where large amounts of nutrients are removed from sandy soils and are not returned (for example, with crops such as alfalfa hay, corn silage, potatoes, sugarbeet or tomatoes). Under these conditions, take samples each year.

To allow time for mailing and analysis, take soil samples in the fall from fields to be fertilized for spring-seeded crops. Because of the rush of harvest and the frequency of poor weather late in the fall, it may be more convenient for some growers to sample in the summer. Take samples at the same time each year for more consistent sample results.

Soil Tests From Other Laboratories

Each year, a number of farmers ask OMAF staff to interpret results from laboratories that are not accredited. Provided the other laboratory uses the identical test used by the OMAF-accredited service and expresses their results in the same units, the OMAF fertilizer requirements for phosphate and potash can be determined. However, there is no assurance of the accuracy of the analysis.

Only OMAF-accredited soil tests can be relied on to provide accurate fertilizer recommendations. Be certain that the service you are using is accredited. To be accredited, a laboratory must use OMAF-approved testing procedures, must demonstrate acceptable analytical precision and accuracy and must provide the OMAF fertilizer recommendations. Soil tests on farms that must complete a nutrient management plan must be carried out at OMAF-accredited labs.

A number of laboratories provide soil tests such as exchange capacity, aluminum and copper. These are not accredited by OMAF because they have not been found to contribute to better fertilizer recommendations. Research has shown that on Ontario soils, use of exchange capacity to adjust potash recommendations can lead to less reliable recommendations than are now provided.

Plant Analysis

Plant analysis measures the nutrient content of plant tissue. Comparing the test results against established normal ranges for the crop can indicate whether the nutrient supply is adequate for optimum growth.

Plant analysis can be a useful supplement to soil testing. It can provide an evaluation of the fertility status of the crop, especially for phosphorus, potassium, magnesium and manganese. It has not been very reliable for nitrogen and zinc.

There is no reliable soil test for boron and copper, so plant analysis and visual symptoms are used for diagnosing deficiencies.

Plant analysis has limitations. Expert help in interpreting the results is often needed, since plant analysis does not usually indicate the cause of a deficiency or the amount of fertilizer required for correcting it. The timing of plant analysis on many vegetable crops is difficult. Rapid growth, and relatively short growing seasons mean that yield loss has often already occurred by the time sample results are available. However, it is a valuable tool for diagnosing nutrient-related problem areas.

Sampling

Time of sampling has a major effect on the results of plant analysis since nutrient levels within a plant vary considerably with the age of the plant. Results are difficult to interpret if samples are taken at times other than those recommended. Nevertheless, plants that are suspected of being nutrient deficient should be sampled as soon as a problem appears.

Samples are best taken from a problem area rather than from the entire field. Separate samples from an adjacent, non-affected part of the field can be valuable for comparison with the samples from the problem area.

Samples for plant analysis should be taken from at least 20 plants distributed throughout the area chosen for sampling. Each sample should consist of at least 100 g (3.2 oz) of fresh material. When taking samples for plant analysis, take care not to contaminate the sample with soil. Even a small amount of soil will cause the results to be invalid, especially for micronutrients.

Sample Preparation

Samples of fresh plant material should be delivered directly to the laboratory. If they are not delivered immediately, they should be dried to prevent spoilage. Samples may be dried in the sun or in an oven at 65°C (149°F) or less. Take precautions to prevent contamination with dust or soil. Avoid contact of samples with brass, copper or galvanized (zinc-coated) metal.

Plant analyses may be obtained from several laboratories in Ontario, see Appendix D, *Accredited Soil-Testing Laboratories in Ontario*, on page 190, for a list of laboratories providing plant tissue analysis. Tissue analysis is not an OMAF-accredited test.

Micronutrient Tests

OMAF-accredited soil tests are available for manganese and zinc. To test for zinc deficiency on corn, the soil test is best used in conjunction with visual symptoms. With manganese, plant analysis, visual symptoms and the soil test are all useful.

OMAF-accredited soil tests are not available for boron, copper, iron or molybdenum. Plant analysis is generally a better indicator of deficiencies of these nutrients.

Great care is required to prevent contamination of soil samples with micronutrients, particularly zinc. Do not use galvanized (zinc-plated) soil sampling tubes to take soil samples for micronutrient tests. Do not use metal containers to collect and mix samples. Clean, plastic containers in good condition should be satisfactory. Soil samples that have contacted galvanized surfaces are unsatisfactory for zinc soil tests. Be careful to keep dust out of the samples.

Micronutrient deficiencies frequently occur in small patches in fields. In these cases, analysis of soil or plants taken from the entire field is unlikely to find the problem. Sample problem areas separately.

Soil pH and Liming

The pH scale ranging from 0 to 14 is used to indicate acidity and alkalinity. A pH value of 7.0 is neutral. Values below 7.0 are acid, and those above 7.0 are alkaline (basic). On mineral soils, most vegetable crops grow well in a soil pH range from 6.0 to 7.5. A range of 5.0 to 6.0 is acceptable on muck soils.

Raising pH

Increase soil pH by broadcasting and incorporating ground limestone into the soil. Field specific rates are determined by soil testing. Table 2–2, *Soil pH at Which Lime Is Recommended for Ontario Field-Grown Crops*, on page 16, shows the pH values below which lime is recommended and the target soil pH to which soils should be limed for different crops. In Ontario, most crops grow quite well at pH values higher than the target pH for which lime is recommended.

Buffer pH

Different soils will require different amounts of lime to bring the pH to a particular desired level. The clay and organic matter content of each soil will affect how easily its pH is altered.

The soil pH is used to determine which soils need to be limed. A separate test, the buffer pH test, determines the amount of lime required. Table 2–3, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, on page 16, indicates the amount of lime required to reach the different "target" soil pH values required for different crops.

Table 2–2.
Soil pH at Which Lime Is Recommended for Ontario Field-Grown Crops

Crop	Soil pH Below Which Lime Is Recommended	Target Soil pH[1]
Coarse- and Medium-Textured Mineral Soils (sands, sandy loams, loams and silt loams)		
Perennial legumes, oats, barley, wheat, triticale, beans, peas, canola, flax, tomatoes, raspberries, strawberries, all other crops not listed below	6.1	6.5
Corn, soybeans, winter rye, grass hay and pasture, turf, tobacco	5.6	6.0
Potatoes	5.1	5.5
Fine Textured Mineral Soils (clay and clay loams)		
Alfalfa, cole crops, rutabaga	6.1	6.5
Other perennial legumes, oats, barley, wheat, soybeans, beans, peas, canola, flax, tomatoes, all crops not listed below or above	5.6	6.0
Corn, rye, grass hay, pasture	5.1	5.5
Organic Soils (peats and mucks)		
All field and vegetable crops	5.1	5.5

[1] Where a crop is grown in rotation with other crops requiring a high pH (for example, potatoes in rotation with cole crops), it is recommended that the soil be limed to the higher pH.

Limestone Quality

Calcitic limestone consists largely of calcium carbonate. Dolomitic limestone is a mixture of both calcium and magnesium carbonates. Dolomitic limestone should be used on soils with a magnesium soil test of 100 or less. It is an excellent and inexpensive source of magnesium for acid soils. Use either calcitic or dolomitic limestone on soils with magnesium test results greater than 100.

Two main factors affect the value of limestone for soil application. One of these is the amount of acid a given quantity of limestone will neutralize when it is totally dissolved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A limestone that will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a limestone, the higher the neutralizing value.

Particle size (fineness rating) also affects the neutralizing value of limestone. Limestone rock has much less surface area to react with acid soil than finely powdered limestone. As a result, it neutralizes acidity much more slowly – so slowly that it is of little value. The calculation of a fineness rating for ground limestone is illustrated in Table 2–4, *Example Calculation of the Fineness Rating of Limestone*, on page 17.

Table 2–3.
Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH

Ground limestone required — tonne/ha (based on Agricultural Index of 75)

Buffer pH	Target soil pH = 7.0[1]	Target soil pH = 6.5[2]	Target soil pH = 6.0[3]	Target soil pH = 5.5[4]
7.0	2	2	1	1
6.9	3	2	1	1
6.8	3	2	1	1
6.7	4	2	2	1
6.6	5	3	2	1
6.5	6	3	2	1
6.4	7	4	3	2
6.3	8	5	3	2
6.2	10	6	4	2
6.1	11	7	5	2
6.0	13	9	6	3
5.9	14	10	7	4
5.8	16	12	8	4
5.7	18	13	9	5
5.6	20	15	11	6
5.5	20	17	12	8
5.4	20	19	14	9
5.3	20	20	15	10
5.2	20	20	17	11
5.1	20	20	19	13
5.0	20	20	20	15
4.9	20	20	20	16
4.8	20	20	20	18
4.7	20	20	20	20
4.6	20	20	20	20

[1] Liming to pH 7.0 is recommended only for club-root control on cole crops.
[2] Add lime if soil pH is below 6.1.
[3] Add lime if soil pH is below 5.6.
[4] Add lime if soil pH is below 5.1.

The Agricultural Index

The Agricultural Index compares the value of different limestone sources. It is a combination of the neutralizing value and the fineness rating. Limestone with a high Agricultural Index is worth proportionately more than limestone with a low index because it may be applied at a lower rate.

$$\text{The Agricultural Index} = \frac{\text{neutralizing value} \times \text{fineness rating}}{100}$$

Table 2–4.
Example Calculation of the Fineness Rating of Limestone

Particle Size	% of sample		Effectiveness Factor		
Coarser than No. 10 sieve[1]	10	x	0.0	=	0
No. 10 sieve to No. 60 sieve	40	x	0.4	=	16
Passing through No. 60 sieve[2]	50	x	1.0	=	50
Fineness Rating				=	66

[1] A No. 10 sieve has wires spaced 2.0 mm apart.
[2] A No. 60 sieve has wires spaced 0.25 mm apart.

Recommendations from the OMAF-accredited soil tests are based on limestone with an Agricultural Index of 75. If the Agricultural Index is known, calculate a specific rate of application using the following equation:

$$\text{Limestone application rate from soil test} \times \frac{75}{\text{Agricultural Index of your limestone}} = \text{Rate of application of your limestone}$$

For example, assume the soil test recommends 9 t/ha of limestone. If the limestone source has an Agricultural Index of 90, the application rate should be 7.5 t/ha (9 x 75/90 = 7.5 t/ha). The Agricultural Index does not provide information about magnesium content.

Effect of Tillage Depth

Lime recommendations presented in Table 2–3, *Lime Requirements to Correct Soil Acidity Based on Soil pH and Soil Buffer pH*, on page 16, should raise the pH of the top 15 cm (6 in.) of a soil to the listed target pH. If the soil is plowed to a lesser or greater depth than 15 cm (6 in.), proportionately more or less lime is required to reach the same target pH. Where shallow tillage depths are used, rates of application should be reduced proportionately. However, more frequent liming will be needed.

Lowering Soil pH

On soils with pH values below 6.5, it is possible to lower the pH (make the soil more acid) by adding sulphur or ammonium sulphate. This may be desirable for some crops, such as potatoes, for scab control. However, it may not be suitable for rotation crops. A soil's pH cannot switch from a low pH to a more moderate pH annually. If the soil pH is above 6.5, it is not practical to lower the soil pH because very large amounts of sulphur or ammonium sulphate will be required.

Fertilizer Recommendations

Changes in Crop or Management

Fertilizer requirements on the OMAF soil test report are for specific crops and management. If manure is applied or legumes are incorporated, adjust fertilizer rates accordingly. For fertilizer adjustments, see Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.

Changing the crop from the original crop specified on the soil test recommendation will require a new fertilizer recommendation. This can be obtained by referring to Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, or Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19, or Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.

Nitrogen

Nitrogen fertilizer recommendations for vegetable crops are based on estimated crop requirements. Recommended rates are presented under the heading *Fertility* in the individual commodity sections in Chapter 6, *Crop Management Recommendations*, starting on page 61. Nitrogen fertilizer rates should be decreased if manure is applied or if the previous crop contained perennial legumes such as alfalfa (see *Changes in Crop or Management*, above).

To protect crop quality and avoid surface and groundwater pollution, the combined application of fertilizer, manure and other sources of nitrogen should not supply more plant-available nitrogen than the crop requires.

Other management practices to reduce the risk of nitrate losses include:

- growing cover crops whenever manure is applied in late summer or early fall
- timing nitrogen applications close to crop nitrogen uptake
- reduced total nitrogen applications

Phosphate and Potash

Phosphate and potash recommendations in this publication are based on OMAF-accredited soil tests. Soil testing is the most accurate method of determining phosphorous and potassium application rates. Crop-specific recommendations are outlined in Table 2–5, *Phosphorus Require-*

Table 2–5.
Phosphorus Requirements: Vegetables on Mineral Soils

Phosphorus Soil Test (mg P/ L of soil)	Rating	Phosphate (P_2O_5) Required kg/ha								
		Beans (lima & snap), Peas	Radishes	Sweet Corn, Asparagus (established)	Sugarbeets	Beets, Carrots, Lettuce, Onions, Parsnips, Rutabagas, Spinach, Horseradish	Potatoes	Cucumbers, Muskmelons, Pumpkins, Squash, Tomatoes[1], Watermelons	Celery, Rhubarb	Broccoli[2], Brussels sprouts[2], Cabbages[2], Cauliflower[2], Eggplant[1], Peppers[1], Asparagus (nursery & new plantings)
0–3	Low	80	80	110	150	180	200	230	230	270
4–5		60	70	100	140	170	200	230	230	260
6–7		50	60	90	140	170	190	220	220	250
8–9		40	60	70	130	160	190	220	220	240
10–12	Medium	30	50	50	130	160	180	210	220	230
13–15		20	50	20	120	150	170	190	210	220
16–20	High	0	40	20	100	140	160	170	190	200
21–25		0	40	20	90	120	140	140	160	170
26–30		0	30	20	70	100	120	110	140	140
31–40	Very High	0	30	0	50	80	90	80	110	110
41–50		0	20	0	30	50	50	50	80	80
51–60		0	0	0	0	30	30	30	50	50
61–80	Excessive	0	0	0	0	0	30	0	0	0
80+		0	0	0	0	0	30	0	0	0

[1] For transplanted tomatoes, peppers and eggplants, apply a starter solution, such as 1 L of 10-34-0 per 100 L of water, or 1 L of 6-24-6 per 75 L at planting.
[2] For transplanted broccoli, Brussels sprouts, cabbages and cauliflower, if no insecticide is used in the planting water, apply a starter solution high in nitrogen such as 20-20-20 at 1 kg/200 L. Under high temperatures and in dry, sandy soils, use half the concentration of fertilizer.

ments: Vegetables on Mineral Soils, above, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.

These recommendation tables should only be used with OMAF-accredited soil tests. Non-accredited tests may use extractants that remove different amounts of nutrients, resulting in inaccurate recommendations if used with the OMAF tables. If manure is applied, the phosphorus and potassium fertilizer rates should be decreased to account for phosphorus supplied through manure applications (see Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Where a soil test is not available, a rough estimate of requirements can be obtained from these tables using the following guidelines:

- If the field has been fertilized regularly for a number of years or heavily in recent years, use one of the rates of phosphate and potash recommended for the MEDIUM soil test rating.
- If the field has received little fertilizer in the past, use one of the rates recommended for a LOW soil test rating.

Soils testing excessive (E) for phosphorus contain much more plant-available phosphorus than required for most crops. The risk of surface water contamination by phosphorus may be increased at higher soil test phosphorus levels. Phosphorus binds tightly to soil particles. As a result, the movement of soil off the field through erosion is also a major factor in determining the risk of surface water contamination.

Wherever soil test results are "very high" or "excessive," applications of any source of phosphorus (manure, fertilizer, processing plant refuse, etc.) should be guided by the Phosphorus Index.

Table 2–6.
Potassium Requirements: Vegetables on Mineral Soils

Potassium Soil Test (mg K/L of soil)	Rating	Potash (K_2O) Required kg/ha									
		Radishes	Beans (snap & lima), Peas	Sweet Corn	Sugarbeets	Tomatoes (paste & fresh market), Cucumbers, Muskmelons, Pumpkin, Squash, Watermelons	Beets, Carrots, Lettuce, Onions, Parsnips, Potatoes, Spinach, Horseradish	Broccoli, Brussels sprouts, Cabbages, Cauliflower, Eggplant, Peppers	Celery, Rhubarb, Rutabagas[1]	Asparagus	Tomatoes[1] (whole pack)
0–15	Low	60	120	170	180	230	230	270	340	420	660
16–30		60	110	160	170	220	220	250	330	400	640
31–45		50	90	140	160	200	210	230	310	360	600
46–60		50	80	110	140	180	190	200	280	320	560
61–80		40	60	80	120	140	160	170	250	280	480
81–100		30	40	50	90	100	130	130	200	250	400
101–120	Medium	30	30	30	70	70	100	100	150	220	340
121–150		20	0	0	20	50	80	80	90	190	300
151–180		20	0	0	0	40	50	50	50	160	280
181–210	High	0	0	0	0	0	0	0	0	130	140
211–250	Very High	0	0	0	0	0	0	0	0	80	70
250+	Excessive	0	0	0	0	0	0	0	0	0	0

[1] For rutabagas and tomatoes on soils with magnesium tests less than 100, the required amount of potash is adjusted downward from the amounts shown in this table to a minimum of 50% at 50 ppm Mg.

Table 2–7.
Phosphorus and Potassium Requirements: Vegetables on Muck Soils

Phosphorus					Potassium				
		Phosphate required kg P_2O_5/ha					Potash required kg K_2O/ha		
Phosphorus Soil Test mg P/L of soil	Rating	Beets Broccoli Brussels sprouts Cabbages Carrots Cauliflower	Lettuce Onions[1] Parsnips Potatoes Radishes Spinach	Celery	Potassium Soil Test mg K/ L of soil	Rating	Broccoli Brussels sprouts Cabbages Cauliflower	Carrots Celery Onions Parsnips Potatoes	Beets Lettuce Radishes Spinach
0–3	Low	100		120	0–15	Low	200	230	100
4–5		100		120	16–30		190	220	100
6–7		100		120	31–45		170	210	90
8–9		100		120	46–60		150	200	80
10–12		90		120	61–80	Medium	120	170	60
13–15		90		110	81–100		90	150	40
16–20	Medium	80		100	101–120		70	120	30
21–25		70		90	121–150		50	80	20
26–30		60		80	151–180		40	40	20
31–40		50		70	181–210	High	0	0	0
41–50	High	30		50	211–250	Very High	0	0	0
51–60		20		40	250+	Excessive	0	0	0
61–80	Very High	0		0					
80+	Excessive	0		0					

[1] If maturity of onions is a problem on organic soils less than 40 cm deep, additional phosphate may be required.

The Phosphorus Index ranks the relative risk of surface water contamination for phosphorus applications made to a particular field. It determines the maximum manure application rates and the required separation distance from watercourses.

Farms that are required to complete a nutrient management plan must establish a permanent vegetated buffer adjacent to any surface water, with a minimum width of 3 m (10 ft) prior to any nutrient application.

Some clay and clay loam soils are naturally high in potassium and do not require any potash fertilizers. Only a soil test can adequately determine potash requirements.

Magnesium

Magnesium is a plant nutrient that is naturally plentiful in many Ontario soils. Soils with OMAF magnesium soil test results below 20 require magnesium application for the production of most crops. Very few Ontario soils have magnesium tests below 20.

If the soil pH is below 6.0, the most effective and inexpensive means of supplying magnesium is with applications of dolomitic lime. If the pH is above 6.0, and the soil test result is 20 or below, magnesium can be supplied by either magnesium sulfate, or sulfate of potash magnesia. Apply 30 kg/ha of actual soluble magnesium. These latter sources of magnesium are usually quite expensive compared to supplying magnesium from dolomitic limestone. See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Potassium competes with magnesium for uptake by the crop. Excessive potash applications can induce a magnesium deficiency. For this reason, it is important to monitor soil potassium levels and to carefully control potash fertilizer applications on low magnesium soils.

Magnesium deficiencies may occur on carrots, celery, tomatoes and spinach. The usual symptom is yellowing of the older leaves while the veins remain dark green. Potato plants may become lighter in colour.

Calcium

Calcium deficiencies rarely occur in vegetables grown on soils with a pH of 6.0–7.5. Calcium-related disorders may occur in some crops (e.g., blossom end rot in tomatoes, blackheart in celery or tipburn in lettuce and cabbage). These problems are caused by difficulties in transporting calcium through the plant, usually resulting from insufficient water.

Several cultural management practices will reduce the occurrence of calcium-related disorders. Efficient nitrogen use will help prevent excessive vegetative growth. Good soil management practices ensure adequate root volume and promote both water and nutrient uptake. Timely irrigation will help prevent calcium shortages in the plant. For calcium application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Micronutrients

Crops vary greatly in how they respond to applications of micronutrients. Highly responsive crops will often respond to additional micronutrients **if** the micronutrient concentration of the soil is low. Medium-responsive crops are less likely to respond and low-responsive crops do not usually respond to fertilizer additions even at low soil micronutrient levels.

Table 2–9, *Response of Crops to Micronutrient Fertilizers*, on page 22, outlines the response of various vegetable crops to micronutrient fertilizers. It is important to note that a high rating does not mean the crop always needs additional micronutrients. Response to any given nutrient only occurs when the soil is already low in that nutrient.

Micronutrient elements should not be combined with insecticide, fungicide or herbicide sprays unless the manufacturer's directions indicate that this may be done or experience has shown that they are compatible. Application of certain micronutrient blends through a fertigation system may cause the emitters to plug.

Mixtures or concentrations of micronutrients in the starter fertilizer may cause phyto-toxicity, especially in adverse weather conditions. For micronutrient application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Boron

Boron should be used with care. There is a fine line between adequate and toxic levels. Take all crops in the rotation into consideration when applying boron. Some crops are more sensitive and experience toxicity at lower levels. On some soils, boron is required for rutabagas, carrots, celery, beets, spinach and cole crops. Boron deficiencies often occur during dry weather. However, the response to boron is often inconsistent. As a result, it has not been possible to develop a reliable soil test. Visual symptoms and tissue analysis are useful for predicting boron requirements in plants.

Table 2–8.
Application Rates for Magnesium, Calcium and Micronutrients

Nutrient	Soil Applied[1]		Source	% Composition	Foliar Applied	
	Nutrient kg/ha	Product kg/ha			Nutrient kg/1,000 L	Product kg/1,000 L
Calcium (Ca)[2]	–	–	calcium chloride	36% Ca	1.9	5.0
	–	–	calcium nitrate	19% Ca	1.9	10.0
Magnesium (Mg)	120–260	2 t/ha	dolomitic limestone	6–13% Mg	–	–
	30	285	epsom salts	10.5% Mg	1.9	18
	30	270	sulphate of potash magnesia	11% Mg	–	–
Boron (B)	1.0–3.0	–	various materials available	12–21% B	0.1–0.3	–
Copper (Cu)	7.0–14.5	28–60	copper sulfate	13–25% Cu	0.5–1.5	2–6
	–	–	copper chelates	5–13% Cu	0.5–1.5	–
Manganese (Mn)[3]	–	–	manganese sulfate	28% Mn	0.5–1.0	1.8–3.6
	–	–	manganese chelates	5–12% Mn	0.5–1.0	–
Molybdenum (Mo)	–	–	sodium molybdate	39% Mo	0.1–0.25	0.25–0.6
Zinc (Zn)	4–14	11–33	zinc sulfate	36% Zn	0.6	1.6
	4–14	–	zinc oxysulfate	18–36% Zn	–	–
	–	–	zinc chelate	9–14% Zn	0.6	–

[1] Double rates for muck soil, except dolomitic limestone.
[2] For blackheart of celery.
[3] For onions use 1.5 to 2.75 kg Mn/1,000 L.

A lack of boron causes a breakdown of the young tissue, resulting in slow growth, tissue cracking, internal blackening and misshapen plants. In addition, the leaves of beets and spinach become twisted, with light spots on the petioles. Internal breakdown (black spot) may occur in the roots or appear on the root surface as external cankers.

Broccoli and cauliflower show leaf rolling, deformed buds, hollow stems and brown heads. Cabbage develops internal dead spots and hollow stems. Celery petioles show reddish-brown spots called "cat-scratches." Rutabagas develop water-soaked internal areas known as "water-core."

Application of boron to mineral soils has not been universally successful. Foliar sprays generally give faster and more effective results. Spray when the young plants are about 8 cm (3 in.) high. A second application may be required.

On request, manufacturers may mix boron fertilizers with ordinary fertilizers. **Do not band boron**. Consult Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, above, for the rates required to correct a boron deficiency.

Copper

Copper soil tests are quite unreliable on Ontario soils, but plant analysis is useful. Copper is unlikely to be deficient on mineral soil, except perhaps on very sandy soils. Copper deficiency does occur on organic soils and is best diagnosed by plant analysis.

Lettuce leaves that are deficient in copper lose their firmness, a condition known as "rabbit ear." The plants become bleached on the stems and leaf margins. Copper-deficient onions produce thin, pale yellow scales. Affected onions have poor colour and decreased storage life. A lack of copper also causes poor colour in carrots.

Extreme care is necessary using foliar sprays with copper sulphate, as foliage is easily damaged. See Table 2–8, above, for rates and sources of copper fertilizers.

When organic soils are first brought into cultivation, copper should be applied to the soil at 14 kg copper/ha (12.5 lb/ac) for each of the first 3 years. Subsequent applications of 5 kg copper/ha (4.5 lb/ac) should be applied every second year thereafter. Addition of copper to muck soils helps to slow the subsidence of the soil. See the section *Subsidence of Peat and Muck Soils*, on page 29.

Table 2–9.
Response of Crops to Micronutrient Fertilizers[1]

Crop	Mn	B	Cu	Zn	Mo	Fe
Asparagus	Low	Low	Low	Low	Low	Med
Beans, snap	High	Low	Low	High	Med	High
Beets, table	High	High	High	Med	High	High
Broccoli	Med	High	Med		High	High
Cabbages	Med	Med	Med	Low	Med	Med
Carrots	Med	Med	Med	Low	Low	
Cauliflower	Med	High	Med		High	High
Celery	Med	High	Med		Low	
Cucumbers	High	Low	Med			
Lettuce	High	Med	High	Med	High	
Oats	High	Low	High	Low	Low	Med
Onions	High	Low	High	High	High	
Parsnips	Med	Med	Med		Low	
Peas	High	Low	Low	Low	Med	
Peppers	Med	Low	Low		Med	
Potatoes	High	Low	Low	Med	Low	
Radishes	High	Med	Med	Med	Med	
Rye	Low	Low	Low	Low	Low	Low
Spinach	High	Med	High	High	High	High
Sugarbeets	High	Med	Med	Med	Med	High
Sweet corn	High	Med	Med	High	Low	Med
Tomatoes	Med	Med	High	Med	Med	High
Turnips	Med	High	Med		Med	

Mn = Manganese B= Boron Cu = Copper
Zn = Zinc Mo = Molybdenum Fe = Iron

[1] Taken, with permission, from the Michigan State University Cooperative Extension Publication E486 *Secondary and Micronutrients for Vegetables and Field Crop* (Table 3, *Relative response of selected crops to micronutrient fertilizers.*)

Manganese

Beans, beets, lettuce, celery and onions are susceptible to manganese deficiency.

Manganese deficiency usually appears as yellowing between the leaf veins. It begins in the younger foliage and may eventually affect the whole plant. Beet symptoms also include russetting, curling and dwarfing of the foliage.

Manganese is less available at high soil pH. It is important not to add more lime than is needed to correct soil acidity. For critical soil test ranges, see Table 2–10, *Manganese Availability Index*, right. This OMAF-accredited index gives an indication of the availability of manganese based on both soil manganese levels and soil pH.

Table 2–10.
Manganese Availability Index

Manganese Soil Test[1]	Suggested Treatments
Greater than 30	Adequate for most crops
15 to 30	Adequate for most crops
Less than 15	Likely insufficient for onions, lettuce, beets
Less than 8	Soil test is quite low but deficiency is not expected in crops other than onions, lettuce, beets

[1] These values are indices of manganese availability based on extractable soil manganese and soil pH.

Foliar applications of manganese have proven to be more effective than soil applications. If this deficiency is identified, apply sprays when the plants are about one-third grown or sooner. Two or more sprays may be necessary at 10-day intervals. Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21, lists the sources and rates for manganese fertilizers.

Molybdenum

Molybdenum deficiencies occasionally occur on beets, cole crops, lettuce, onions and spinach crops grown on sandy, acid soils. Deficiency symptoms on cole crops start with cupping of the leaf margins and yellowing between the veins of the younger leaves. As the leaves develop, twisting of the midrib and irregular development of the leaf tissue cause a strap or whip-like appearance known as "whiptail."

In other crops, the early symptoms of molybdenum deficiency are similar to nitrogen deficiency. Later symptoms are interveinal mottling of leaves with chlorotic areas becoming puffy, marginal cupping and scorching of leaves and twisting and distortion of younger leaves.

Molybdenum availability to plants increases with an increase in pH. Consequently, liming acid soil may be a good practice to overcome molybdenum deficiency. Deficiency may occur even in neutral soils if heavy cropping has depleted soil molybdenum reserves.

For recommended molybdenum fertilizer rates, refer to Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21. Molybdenum can also be applied in the transplanting water at the rate of 30–40 g of sodium molybdate per 100 L of water, each plant receiving 0.3 L of this solution.

Zinc

Corn and onions may show zinc deficiency in Ontario. Zinc deficiency has been reported in beans in other areas but

Table 2–11.
Zinc Soil Index Interpretation

Zinc Soil Index[1]	Suggested Treatments
Greater than 200	Contamination of the sample or of the field is likely.
25 to 200	Soil zinc availability is adequate for most field-grown crops.
15 to 25	Zinc availability is adequate for most field crops but is bordering on deficiency for corn. If the field sampled is uneven in soil texture, pH or erosion, some areas may respond to zinc applications. Deficiency symptoms at the 4-to-6 leaf stage are a reliable indication of zinc deficiency.
Less than 15	Zinc is likely to be deficient for corn and should be applied in the fertilizer.

[1] These values are indices of zinc availability based on extractable soil zinc and soil pH.

appears to be rare in Ontario. Symptoms in corn include broad white bands near the base of leaves emerging from the whorl. If the deficiency is mild, the veins will often stay green.

High phosphorus in the soil and/or in the fertilizer can cause or increase the severity of zinc deficiency. Apply only the recommended amount of phosphorus. Use of animal manures can prevent or reduce zinc deficiency.

Zinc deficiency can be prevented by the application of zinc fertilizer to the soil at a rate of 4 kg Zn/ha. Broadcasting up to 14 kg Zn/ha will correct a deficiency for 3 years. No more than 4 kg Zn/ha should be banded. Early in the growing season, foliar sprays can be used to correct a deficiency after the symptoms have appeared.

Table 2–11, *Zinc Soil Index Interpretation*, above, gives an indication of the availability of zinc based on both soil zinc levels and soil pH. For zinc application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Nutrient Management Plans

A nutrient management plan matches the nutrients required by the crop with the nutrients available in manure, from cover crops or legumes plowed down, in commercial fertilizer and in the soil. Analysis of nutrients contained in the manure, along with soil test results and crop requirements, help determine application rates and additional commercial fertilizer requirements.

Following a nutrient management plan will optimize the nutrients applied to the crop for crop yield and profitability, while reducing the risk of surface or groundwater contamination by nitrogen or phosphorus.

Table 2–12.
Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down

Type of Sod	For All Crops, Deduct From N Requirement kg N/ha
Less than ⅓ legume	0
⅓ to ½ legume	55
½ or more legume	100
Perennial legumes seeded and plowed the same year	45[1]
Soybean and field bean residue	0

[1] Applies where the legume stand is thick and over 40 cm high.

Regulations under the *Nutrient Management Act* require some farmers to complete nutrient management plans (NMPs) for their farming operations. This requirement applies to new livestock operations and to operations expanding above 300 nutrient units. The above regulations will also apply to existing operations that generate 300 nutrient units or more on July 1, 2005.

Other farms that receive and apply nutrients may come under a requirement to complete an NMP at a future date. Outside of the legal obligation, many farmers are completing nutrient management plans on their own, because it saves them money and improves the management of inputs on their farms.

Adjustments to Fertilizer Recommendations

Legumes Plowed Down

When sod containing perennial legumes such as alfalfa, trefoil and clover are plowed under, they supply an appreciable amount of nitrogen to the following crop. Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, above, shows reductions that should be made in nitrogen applications to crops following sod containing legumes.

Manure

A large number of Ontario farms produce livestock, generating over 33 million tonnes of manure per year. Proper management of the nutrients from manure is essential for optimum economic benefit to the farmer with minimal impact on the environment.

Table 2–13.

Average Amounts of Available Nutrients for Different Types of Manure

Nutrient values based on average analysis results for over 700 samples. There are large variations between different manures, so a manure analysis is your best guide to nutrient availability.

Manure	Average Dry Matter	Available Nitrogen[1] Spring 1 day	Available Nitrogen[2] Spring not incorp.	Available P_2O_5[3]	Available K_2O[4]
		kg/1,000 L (lb/1,000 gal)			
Liquid dairy	6.5%	1.6 (16)	.6 (6)	.7 (7)	3 (30)
Liquid hog	3.6%	2.6 (26)	.7 (7)	1.1 (11)	2 (20)
Liquid poultry	8.0%	6.1 (61)	1.7 (17)	2.5 (25)	3.4 (34)
		kg/tonne (lb/ton)			
Solid poultry	49%	11.5 (21)	6 (12)	9 (18)	12.5 (25)
Solid dairy	20%	1.5 (3)	0.7 (1.4)	1.5 (3)	5.5 (11)
Solid beef	27%	1.5 (3)	0.75 (1.5)	1.5 (3)	7 (14)

[1] Nitrogen based on spring application, incorporated within 24 hours.
[2] Nitrogen based on spring application, not incorporated (i.e., on soil surface for over 7 days).
[3] Phosphate from manure or biosolids is assumed to be 40% as available in the year of application as that in manufactured fertilizer.
[4] Potash from manure or biosolids is assumed to be 90% as available in the year of application as that in manufactured fertilizer.

The Value of Manure

The value of manure in crop production is often underestimated. In addition to nitrogen, phosphorus and potash, manure contains many secondary nutrients and micronutrients. However, they are not necessarily in the proportions needed for specific crop conditions.

See Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, above. The data in this table is presented for information only. More specific values are contained in the NMAN program or workbook, and these values are continually updated as new data from manure analyses is entered into the database. Nutrient management plans that are not based on analytical results must be based on the NMAN values.

Manure also contains valuable organic matter that helps to build and maintain soil structure.

Long-Term Value of Manure

The long-term availability of phosphorus (P), potassium (K), magnesium, zinc or manganese from previous manure applications is best estimated by soil testing. The application of large quantities of manure over time can result in high levels of available phosphorus and potassium in soils. Manure also contributes other plant nutrients and organic matter to soil.

Fifty to sixty per cent of the nitrogen available in manure is used by the crop or is lost during the first growing season following application. The remaining organic nitrogen becomes available in small, diminishing quantities in the succeeding years. The amount of nitrogen left over from a previous year's application is usually too small to make a practical difference in nitrogen recommendations for a crop. However, where manure is applied regularly to the same field, there may be significant residual nitrogen available for a crop.

Manure Analysis

The quantities of nutrients contained in manure vary from farm to farm, especially the phosphorus and potash components. The type of livestock, ration, bedding, added liquids and storage system all affect the final nutrient analysis.

Manure analysis is available from several laboratories in Ontario. See Appendix D, *Accredited Soil-Testing Laboratories in Ontario*, on page 190. An analysis should be performed after complete agitation or thorough mixing, each time the storage is emptied (e.g., spring and fall) or each time a new manure source is used. After several analyses of a particular manure source, a trend in the results will be evident, and sampling can be limited to major changes in ration or other management factors.

When submitting a sample for analysis, fill a 2-L plastic jar half-full, cover and place in a plastic bag and store in a cool place until shipping. Analysis should include total nitrogen, ammonium-nitrogen (NH_4-N), phosphorus, potassium and dry matter. Ontario labs send back analysis results with percentages for nitrogen, phosphorus, potassium and dry matter as well as mg/kg (or ppm) of ammonium-nitrogen. Percentages for phosphorus and

potassium from manure are converted to commercial P_2O_5 and K_2O equivalents, and commercial fertilizer reductions are given. Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24, summarizes average amounts of nutrients for different types of manure.

Application

Soil test results and yield goals will determine the maximum economic application rate and/or additional fertilizer requirements. If manure is applied to meet the entire nitrogen requirements of a corn crop, there is usually more P and K applied than the crop will remove, and soil test levels will increase.

For liquid manure, an application goal of two-thirds to three-quarters of the nitrogen requirements for a corn crop is a reasonable compromise. The release of nitrogen is much less predictable with solid manure because of the high carbon content of the bedding material.

Soil compaction is a problem for many farmers. It leads to, among other things, poor drainage and decreased aeration. The best way to reduce or avoid soil compaction is to spread manure when the soil is dry. Loads should be kept below about 5 tons per axle. These points should be considered in the selection of spreading equipment and in the timing of spreading (i.e., summer vs. spring vs. fall application). Spring spreading is often carried out on fields that are too wet, and it is not unusual for strips of stunted crops to serve as an indicator of the wheel track locations.

> See OMAF Publication 611, *Soil Fertility Handbook*, for more detailed information on manure and nutrient values.

Environmental Concerns

All farmers have a responsibility to prevent contamination of surface and groundwater sources. If manure is applied to unprotected cropland, nitrogen can be carried off-site by rainwater. Phosphorus-rich soil particles can also be carried to streams by soil erosion. Soil conservation practices can reduce the chances of nutrients polluting waterways.

Groundwater contamination can occur by mass flow through soil cracks and holes to groundwater or through leaching of nitrates through the soil. Shallow soils over bedrock, soil with a water table close to the surface and very sandy soils are of particular concern.

Spreading manure in the winter and early spring is not recommended because of the potential for runoff to surface water. In years when winter spreading may be necessary, take care to select fields where there is minimal risk of runoff to surface water. If your farm requires a nutrient management plan, refer to Ontario Regulation 267/03 for specific requirements for winter application of manure.

Liquid manure should not be spread within 10 m (33 ft) of a watercourse. Solid manure should have a 5-m (16-ft) buffer zone. There are a number of factors that may increase the size of the buffer zone that producers should use, such as slope of the land adjacent to the watercourse and soil hydrologic group. Producers required to have a nutrient management plan under the *Nutrient Management Act*, 2002, must follow the direction provided in the Ontario Regulation 267/03.

Tile drain effluent can become contaminated if manure enters a catch-basin or travels through soil cracks to the tiles. With liquid manure, maintain a 10-m (33-ft) buffer around a catch-basin or surface inlet. Use a 5-m (13-ft) buffer with solid manure. Tillage prior to application of liquid manure is recommended.

Food Safety Concerns

Fruit and vegetable crops can become contaminated in the field if they contact microbes that cause human illness. These microbes can come from manure and manure-based composts. They can contaminate fruit or vegetables by direct soil-to-produce contact or through rain-splashed soil. Examples of harmful microbes are some, but not all, strains of *E. coli*, *Salmonella* and *Campylobacter*.

The longevity of harmful microbes in manure is not well known. Proper composting of manure, which results in heating to a specific temperature for a specific period of time, will reduce the level of most pathogens. Aged manure (manure stored in piles and occasionally turned) may contain considerably more pathogens than properly composted manure (manure turned/mixed frequently, temperature monitored and maintained).

Composting may not completely eliminate all pathogens, so the appropriate precautionary measures should be taken when manure is used. Incorporation of manure will minimize but may not eliminate the risk of microbial contamination of produce. For more information on food safety concerns in vegetable crops, see the section *Food Safety*, on page 46.

Table 2–14.
Fertilizer Materials:
Primary Nutrients

Nitrogen Materials	Form	% Nitrogen (N)
Ammonium nitrate	Dry	33 to 34
Urea	Dry	45 to 46
Ammonium sulfate	Dry	20
Calcium ammonium nitrate	Dry	27
Calcium nitrate	Dry	15.5
Aqua ammonia	Liquid[1]	20
Urea ammonium nitrate (UAN)	Liquid	28
Anhydrous ammonia	Liquid[1]	82
Phosphate Materials		**% Phosphate (P_2O_5)**
Single superphosphate		20
Triple superphosphate		44 to 46
Monoammonium phosphate (11-52-0)		48 to 52
Diammonium phosphate (18-46-0)		46
Potash Materials		**% Potash (K_2O)**
Muriate of potash		60 to 62
Sulfate of potash		50
Sulfate of potash magnesia (11%Mg)		22
Potassium nitrate (13-0-44)		44

[1] Liquid under pressure.

Biosolids

Biosolids from off-farm sources can be a useful source of nutrients and organic matter. Guidelines are available from OMAF and the Ministry of the Environment (MOE). A Certificate of Approval for land application is required and is available from MOE. An analysis of nutrients applied should be given by the applicator to the landowner whenever biosolids are applied. **Sewage sludge from municipal sewage treatment plants may not be applied to vegetable-producing land within 12 months of harvest.**

Processing vegetable growers should always check with the processor before applying sewage sludge on ground intended for vegetables.

Fertilizer Materials

Nitrogen fertilizer materials are available in dry or liquid forms. In most cases, the different sources will produce equal yields, although there are some limitations to the use of these materials (see the section *Toxicity of Fertilizer Materials*, on page 27). The grower's choice of material should therefore depend on availability, equipment for handling and cost per kilogram of nitrogen, plus the cost of application.

Table 2–15.
Fertilizer Materials:
Secondary and Micronutrients

A number of micronutrients are available as chelates, with various formulations and nutrient contents. Check the product labels. The effective use rate for chelated products is the same as for other formulations.

Calcium (Ca)	
Calcium chloride	36% Ca
Calcium nitrate	19% Ca
Liming materials and gypsum also supply calcium	variable %
Magnesium (Mg)	
Dolomitic limestone	6%–13% Mg
Epsom salts (magnesium sulfate)	10.5% Mg
Sulfate of potash magnesia	11% Mg
Boron (B)	
Sodium borate	12%–21% B
Copper (Cu)	
Copper sulfate	13%–25% Cu
Copper chelates	5%–13% Cu
Manganese (Mn)	
Manganese sulfate	28% Mn
Molybdenum (Mo)	
Sodium molybdate	39% Mo
Zinc (Zn)	
Zinc sulfate	36% Zn
Zinc chelates	9%–14% Zn
Zinc oxysulfate	18%–36% Zn

The nitrogen recommendations in the commodity sections of Chapter 6, *Crop Management Recommendations*, starting on page 61, are measured in kilograms of elemental (actual) nitrogen (N), not kilograms of fertilizer material. Table 2–14, *Fertilizer Materials: Primary Nutrients*, and Table 2–15, *Fertilizer Materials: Secondary and Micronutrients*, above, show the percentage of actual nutrient contained in different fertilizer materials.

In addition to the micronutrient sources listed in Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21, various fertilizer companies sell pre-mixes containing one or more micronutrients.

Soluble Salts in Farm Soils

High concentrations of water-soluble salts in soils can prevent or delay germination of seeds. They can also kill established plants or seriously retard their growth.

Due to excess soil water levels in the fall through spring, Ontario field soils are naturally low in soluble salts. Soluble salts therefore rarely cause a problem in field vegetable production and are not routinely measured in soil

Table 2–16.
Soil Conductivity Reading Interpretation

Conductivity "Salt" Reading millisiemens/cm	Rating	Plant Response
0–0.25	L	Suitable for most plants if recommended amounts of fertilizer are used.
0.26–0.45	M	Suitable for most plants if recommended amounts of fertilizer are used.
0.46–0.70	H	May reduce emergence and cause slight-to-severe damage to salt-sensitive plants.
0.71–1.00	E	May prevent emergence and cause slight-to-severe damage to most plants.
Greater than 1.0	E	Expected to cause severe damage to most plants.

tests. Vegetable transplants, however, can experience salt problems. Some direct-seeded crops can also experience salt problems, usually resulting from fertilizer management practices. Symptoms resemble damping-off and/or uneven growth.

Soluble salts in soils can result from excessive applications of fertilizers and manures, runoff of salts applied to roads and chemical spills on farmland. High concentrations of soluble salts in or near a fertilizer band can cause serious early plant growth problems without seriously affecting the salt concentrations in the remainder of the soil.

Plant growth is most affected by soluble salts when the plants are small, during dry soil conditions. A given amount of salt in a soil provides a higher salt concentration in soil water if the amount of water is small. Soluble salts also interfere with the uptake of water by plants.

Soluble salts can be measured readily in the laboratory by measuring the electrical conductivity of a soil-water slurry. The higher the concentration of water-soluble salts, the higher the conductivity. Table 2–16, *Soil Conductivity Reading Interpretation*, above, provides an interpretation of soil conductivity reading as read in Ontario field soils in the 2:1 (water:soil paste) procedure used by the OMAF-accredited soil testing program.

Toxicity of Fertilizer Materials

All fertilizer salts are toxic to germinating seeds and to plant roots if applied in sufficient concentration near the seed. Fertilizers vary in toxicity per unit of plant nutrient due to:

- differences in the amount of salts contained in the fertilizer per unit of plant nutrient
- differences in the solubility of the salts in the soil
- specific toxicity — a few specific materials or elements are particularly toxic (for example, ammonia and boron).

Nitrogen Fertilizers

Ammonium nitrate, monoammonium phosphate and ammonium sulphate are similar in toxicity. They are all much safer than anhydrous ammonia, aqua ammonia or urea.

Diammonium phosphate is more toxic than monoammonium phosphate but less toxic than urea. Take more care, particularly with sensitive seeds and on coarse-textured soil (sand and sandy-loam), than is required with ammonium nitrate or monoammonium phosphate.

Because anhydrous ammonia and aqua ammonia are extremely toxic fertilizers, they should not be placed near seeds. It is preferable to make preplant applications perpendicular to the direction in which the crop will be planted.

Urea is toxic when banded with or near the seed but is safe when broadcast at rates normally used. Fertilizers containing more than half as much nitrogen as phosphate frequently contain urea.

Phosphate Fertilizers

Phosphate fertilizers are usually low in toxicity, because a large portion of the phosphate is precipitated in the soil before it can reach the plant roots. The concentration of readily available phosphorus in soil solution at any one time is very low. No limit is normally set for the safe rate at which phosphates may be applied with, or near, the seed of field-grown crops.

Diammonium phosphate is more toxic than other phosphate fertilizers. (See the section *Nitrogen Fertilizers*, above.)

Fertilizers Containing Micronutrients

Fertilizers containing micronutrients (boron, copper, iron, manganese or zinc) are more toxic than the same grades without micronutrients, and maximum safe rates should be reduced. **Boron is particularly toxic and should not be banded.**

Foliar Fertilizers

Micronutrients can be supplied to the crop through foliar fertilization, particularly in instances where a deficiency is due to a tie-up of these nutrients in the soil. Quantities of nutrient that can be applied this way are limited because of the danger of burning the leaves. If you are applying more than one micronutrient through foliar application, the possibility of leaf damage becomes greater. Check pesticide labels before mixing foliar nutrients with any pesticide spray. Many chelated micronutrients will form a lumpy precipitate in the spray tank if mixed with pesticides.

Guidelines for Safe Rates of Nutrients Applied at Seeding

Fertilizer toxicity varies widely, depending on the amount of soil moisture. To ensure completely safe rates of banded fertilizer for all seeding conditions would require extremely low rates of application. The maximum safe rates suggested in Chapter 6, *Crop Management Recommendations*, starting on page 61, will probably reduce or delay germination, or retard growth in up to 10% of the cases where they are used.

In most cases, it is advisable to use lower rates of fertilizer at seeding. If fertilizer requirements are high, it may be better to broadcast and/or side-dress most of the fertilizer required and to band only a small portion at seeding.

Fertilizers containing the micronutrients boron, copper, iron, manganese and zinc are more toxic, and the safe rates recommended at seeding will be lower than normally recommended.

Fertilizer Placement

Phosphorus is very important for early growth. It does not move readily in the soil and is more available if placed near the seed. For transplant crops, the use of high-phosphorus starter solution is a profitable practice, especially under cool soil conditions.

Nitrogen fertilizers readily dissolve in the soil water and move easily through the soil to the plant roots. From a crop production standpoint, placement of nitrogen is less important than for phosphorus. Part of the nitrogen requirement is usually broadcast, injected or worked into the soil before planting.

Too much potassium applied in a band at planting or in the transplant water can injure young seedlings and reduce crop yield and quality. The danger of fertilizer injury is greater on sands and sandy loams than on silt loam and clay loam soils. On the coarse-textured sand and sandy loams, part of the potassium fertilizer requirements should be broadcast and worked into the soil before planting.

Side Dressing

In many vegetable crops, nitrogen response can be enhanced by splitting the distribution between preplant and side-dressed applications. This practice stages the application of the nitrogen to coincide with the crop's rapid growth phase. It also helps minimize leaching and prevent plants from putting on too much vegetative growth. The timing and amount of nitrogen side-dressing must be judged from the appearance and size of the plants. On coarse, sandy soil, it may be advisable to side-dress potash as well as nitrogen.

Fertigation

Trickle or drip irrigation systems can be used to apply fertilizers; this is often called fertigation. Generally, nitrogen and potassium can be applied in this way during the growing season. Application of phosphorus and micronutrient fertilizers can cause clogging and plugging of emitters. For more information, see the section *Fertigation*, on page 46.

3. Soil Management

Most of the prime vegetable-growing soils are light in texture. Vegetable production tends to be a very intensive process, usually involving a lot of tillage. Maintaining soil organic matter levels is a challenging and ongoing process. Soil organic matter helps maintain soil structure, enhances soil moisture-holding capacity, increases the soil's ability to hold nutrients and improves drainage. Maintaining adequate soil organic matter levels can help maintain crop yields, particularly under adverse conditions.

Soil Quality

Soil quality is the measure of a soil's health and its ability to resist erosion, compaction and other stresses, while maintaining economic productivity. Many factors are assessed to determine a soil's health. A healthy soil:

- has good soil structure and minimal compaction
- resists crusting
- has an abundance of earthworms
- smells good
- readily decomposes residue
- has good drainage, water movement and water-holding capacity
- encourages seedling emergence and root growth
- produces uniform crop growth and colour

A healthy soil will also have optimal ranges of nutrient levels, pH and organic matter. It is resistant to wind, water or tillage erosion.

Assessing the soil quality for each field and taking steps to maintain or improve it will ensure long-term productivity. Maintaining soil quality is a continuous process. Some measures are easy and relatively inexpensive to implement, while others require more effort and commitment to put in place. Table 3–1, *Maintaining or Improving Soil Quality*, on page 30, displays a variety of measures that can be used to help maintain or improve various aspects of soil quality.

For further information on soil management, see the OMAF/Agriculture and Agri-Food Canada booklet *Best Management Practices: Soil Management*, Order No. BMP06.

Subsidence of Peat and Muck Soils

Cultivated peat and muck soils decompose or subside (oxidize) gradually at rates of 1–3 cm/yr. Maintaining a high water table and a low pH reduces the rate of subsidence to less than 0.05 cm/yr. A very wet (or very acidic) soil does not give maximum yields and is likely to be flooded when rainfall is intense. Wet spots may also be difficult to work and may result in uneven crop growth. Keeping fields well drained during the growing season will ensure optimal crop growth. Raising the water table in the fall and winter will help reduce the rate of subsidence.

Research has shown that copper (Cu) applied as fertilizer has the residual effect of slowing down degradation (subsidence) by about 50%. Apply 14 kg of Cu/ha (12.5 lb/ac) annually to peats and mucks in the first 3 years of cultivation and up to 5 kg of Cu/ha (4.5 lb/ac) every second year thereafter, particularly when onions, carrots or lettuce are grown on the soils.

Table 3–1.
Maintaining or Improving Soil Quality

Measure	Comments
Easy/less expensive	
Use of cover crops	Use cover crops with fibrous root systems to improve soil structure, particularly at the soil surface. Use cover crops with tap roots to penetrate dense soil layers. Cover crops provide protection from erosion.
Soil testing and accurate application of fertilizer and lime	Adequate pH and fertility will improve crop growth.
Reducing tillage and using residue management	Using fewer tillage passes to prepare the seedbed will: • leave more residue on the surface to protect against wind and water erosion • reduce soil organic matter loss • leave soil aggregates intact to reduce crusting potential
Adding organic matter in the form of manure or compost	Regularly adding organic materials to the soil will help increase organic matter levels in the soil, improve soil structure, increase the water-holding capacity and make the soil less prone to erosion.
Erosion control measures	Simple measures such as buffer strips, drop structures (rock chutes or drop pipes), tile outlet protection and strip cropping greatly reduce soil erosion. More expensive structures such as water and sediment control basins help protect fields from major soil loss.
Significant management changes or investment required	
Minimum tillage	Switching to minimum or no-till systems will leave more residue on the surface and help protect the soil. It will also improve soil structure. It requires investment, equipment and management changes.
Crop rotation including a mix of cereal, legume or grass crops	Rotating vegetable crops over a period of 3–4 years with cereal, legume or grass crops will improve soil structure, improve the water-holding capacity and make the soil less prone to erosion.
Planting windbreaks	Windbreaks protect the soil and prevent sandblasting and desiccation of the crop and may provide microclimate benefits. Results are seen in a few short years after planting, and the benefits can last a lifetime.
Planting windstrips	Established each year, wind strips can be adapted to many different crops. Similar to windbreaks, windstrips protect the soil and prevent sandblasting and desiccation of the crop and may provide microclimate benefits.
Improving drainage	Tile drainage will remove excess water, allowing for more timely field operations, reduced compaction potential and improved crop growth.

Tillage Systems

The traditional role for tillage systems has been to provide weed control and prepare a seedbed that will give good crop stands and high yields. More recently, tillage and cropping systems have been changed to accomplish the same goals while reducing soil erosion through less intensive or no cultivation. Newer, more effective herbicides have reduced the need for aggressive mechanical weed control programs. Other factors favouring reduced tillage are savings on fuel and labour.

Base any decisions to switch to a different tillage system on the system's compatibility with the farm's soil types, slopes, drainage and spring soil temperatures. Tillage impacts erosion control as well as the timeliness of fieldwork and the potential for controlling weeds, insects and diseases.

No one tillage system is best for Ontario conditions. Variability in soils, crops, climate and management mean tillage systems must be fine-tuned for each farm operation. In fact, the tillage system may rotate with the crop, allowing for the use of the most appropriate tillage for each crop.

Conventional Tillage

Conventional tillage is any system that attempts to bury most of the previous crop residue, leaving less than 30% of the soil surface covered with residue after planting. Usually the moldboard plow is used in conjunction with a variety of other tillage implements.

The principal advantages of the moldboard system are that the machinery is familiar and widely available and the system is adaptable to a wide range of soil conditions. Moldboard plowing increases soil porosity, allowing for air exchange, root proliferation and water infiltration, especially when rainfall is above average. However, the increased porosity can be lost with excessive secondary tillage, soil compaction or in soils with

poor structural stability. Many livestock producers view the moldboard plow as the most effective tool for incorporating manure and breaking up sod fields.

The main weaknesses of the moldboard system include high costs of equipment, fuel and additional labour associated with seedbed preparation. With little or no residue cover, there is a high risk for soil erosion by wind and water. Adjusting the moldboards so that the soil is not completely inverted and some residue is left on the surface can mitigate some of these problems.

Conservation Tillage

Conservation tillage systems are designed to leave residue from the previous crop on the soil surface. This provides more protection against erosion than conventional tillage.

Conservation tillage can be achieved with a variety of implements. The chisel plow has been the most widely adopted conservation tillage tool in Ontario. Tandem and offset discs are also being used extensively in some areas of the province.

Fall chisel plowing with twisted shovel teeth will often leave ridges in the field the following spring. This can lead to extra costs in secondary tillage (more passes), uneven seed beds and occasionally excessive soil drying. Many of these problems can be overcome by:

- using sweep teeth on all or part of the chisel plow
- adding a levelling bar or harrows to the rear of the chisel plow
- practicing timely secondary tillage in the spring

No-Till Systems

No-till systems provide the greatest opportunity to leave protective crop residues on the soil surface. They also have the greatest potential for reducing tillage costs. One drawback of no-till is the increased reliance on "burn-down" herbicides.

Numerous options exist both in the original design and in the modifications available for row crop planters or seed drills to be considered capable of "no-till." Increasingly, there are more modifications available for vegetable transplanters to assist in planting through crop residues.

No-till is a technique that can be used relatively easily with some vegetable crops. The maintenance of surface crop or cover crop residues offers several benefits, including:

- the potential for weed suppression
- interference with the movement of some pests, e.g., Colorado potato beetle
- reduction of sand blasting and wind dessication
- reduction of soil water losses

However, concerns with insects and diseases, precision seeding and crop debris during machine harvest remain a challenge for many vegetable crops.

For further information on tillage systems, see the OMAF/Agriculture and Agri-Food Canada booklets:

- *Best Management Practices: Field Crop Production*, Order No. BMP02
- *Best Management Practiced: No-Till: Making It Work*, Order No. BMP11
- *Best Management Practices: Soil Management*, Order No. BMP06

Cover Crops

Cover crops play a major role in Ontario by providing ground cover to reduce erosion and by adding organic matter to improve or maintain the soil. Following is information on some of the more commonly used cover crops. See also Table 3–2, *Characteristics of Cover Crops Grown in Ontario*, on page 32.

Grasses

Grasses have fine, fibrous root systems that are well suited to holding soil in place and improving soil structure. Grass species suitable for cover crops are fast growing and relatively easy to kill (either chemically, mechanically or by winter temperatures). Grasses do not fix any nitrogen out of the atmosphere, but they can scavenge large quantities from the soil.

Ryegrass (Annual, Italian or Perennial)

Ryegrass is direct seeded in the spring or from August to mid-September. It can also be seeded with a nurse crop in the spring or broadcast into corn in late June—early July with some success.

Annual ryegrass gives the most top growth in the seeding year. It often heads 6–8 weeks after seeding. Italian ryegrass (a biennial) does not head in the seeding year, so

Table 3–2.
Characteristics of Cover Crops Grown in Ontario

Species	Normal Seeding Time	Seeding Rate kg/ha	Nitrogen[1] Scavenging Potential	Overwintering Characteristics	Potential Weed Problem From Volunteer Seed	Nematode Rating[2]	
						Lesion	Root-knot
Grasses							
Ryegrass	April to May or Aug to early Sept	13–17	moderate	Annual & Italian: partial survival Perennial: overwinters	no	—	—
Spring cereals	Mid-Aug to Sept	100–125	moderate	killed by heavy frost	no	+	—
Sorghum sudan	June to Aug	50	moderate-high	killed by frost	no	NH[2]	—
Pearl millet	June to Aug	9–10	moderate-high	killed by frost	no	NH[2]	NH[2]
Winter wheat	Sept to Oct	100–125	moderate-high	overwinters well	no	+	NH
Winter rye	Sept to Oct	100–125	high	overwinters very well	no	+[3]	NH
Legumes[4]							
Hairy vetch	Aug	20–30	low-moderate (fixes N)	overwinters	no	++	+
Red clover	Mar to April	8–10	low-moderate (fixes N)	overwinters	no	++	+++
Sweet clover	Mar to April	8–10	low-moderate (fixes N)	overwinters	no	—	—
Non-Legume Broadleaves							
Buckwheat	June to Aug	50–60	moderate	killed by first frost	yes	+++	NH
Oilseed radish[5]	Mid-Aug to early-Sept	10–14	high	killed by heavy frost	yes	NH[2]	NH[2]

Nematode Rating Codes: — = poor or non-host + = ability to host NH = non-hosts

[1] The potential for nitrogen uptake is influenced by seeding date, stand establishment and growing conditions. Nitrogen fixing legumes are less likely to take up residual nitrogen.
[2] Varietal differences in cover crop species may affect nematode reaction.
[3] Rye whole season rating would be higher (+++).
[4] Some diseases caused by *Pythium* and *Phytophthora* can be more severe after legume cover cropping.
[5] Oilseed radish residues can be toxic or allelopathic to subsequent crops if the following crop is planted too closely after green manuring. Allow the green manure residues to break down or dessicate before planting the next crop.

top growth is considerably less. However, it has the largest, densest root system of the three types.

Annual and Italian ryegrass usually suffer considerable winterkill, but part of the stand may survive. Perennial ryegrass normally survives the winter.

Cautions: Establishment and growth of ryegrasses can be poor during very hot, dry weather. It can be difficult to kill overwintering ryegrass merely with cultivation or discing. The nitrogen tied up in ryegrass releases more slowly than from many other cover crops. As a result, corn after ryegrass often requires an extra 20–30 kg/ha (18–27 lb/ac) of nitrogen.

Spring Cereals

Spring cereal cover crops are usually seeded for plow-down. Stands seeded from mid-August to mid-September will have 20–40 cm (8–16 in.) of growth by freeze-up. The stand is generally killed by late, hard frosts.

Volunteer spring cereals are sometimes left to grow until freeze-up as a cover crop. Stands may not be very uniform.

On erosion-prone knolls, spring cereals often have little growth and have been observed to "blow off" by spring. This may open the whole field to erosion.

Cautions: Very early seeding may result in considerable growth by freeze-up. If left unplowed in the fall, the

mat of dead residue will slow soil drying and warming in the spring, which can cause problems in early-seeded crops.

Sorghum Sudan and Forage Pearl Millet

Sorghum sudan and forage pearl millet are warm-season grasses. They are extremely sensitive to frost. They have extensive root systems and produce a significant amount of top growth. They are both a good option for a mid-summer green manure crop to improve the soil after early harvested vegetable crops.

Plant in mid-June, after all threat of frost is past. These crops benefit from the warm temperatures of early to mid-summer. Approximately 50 kg/ha (44.5 lb/ac) of N helps the crop achieve maximum top growth. A preplant herbicide treatment is recommended for crop establishment.

Planting certain cultivars of sorghum sudan and forage millet in rotation with high-value horticultural crops can reduce plant parasitic nematode soil populations below economic thresholds. More than 1 year of a nematode-suppressing variety may be required to effectively reduce nematode levels.

These cover crops may not entirely replace fumigation under high levels of nematode pressure. However, they are useful in maintaining low levels and preventing future nematode resurgences. Sorghum sudan and pearl millet do not have to be incorporated green for nematode suppression. Canadian Forage Pearl Millet 101 reduces nematode populations by inhibiting the ability of nematodes to reproduce in its root system.

Cautions: Mow before the crop reaches 1 m (3 ft) in height. This encourages tillering and prevents the stalks from becoming woody and slow to decompose. Do not mow shorter than 15 cm (6 in.) to ensure regrowth

Winter Rye

Winter rye is seeded from September into mid-October, often following vegetable crops. It grows until freeze-up and then commences growth again, slightly earlier than winter wheat, in late March to early April. The growth rate is very rapid during May. Kill the stand with either tillage or a herbicide in late April or early May.

Winter rye can be seeded later than any other crop and still survive over winter. For good ground cover and erosion protection, it should be seeded at least a month before freeze-up. Winter rye is one of the most consistent, flexible and economical cover crops available.

Cautions: Rye will grow very rapidly under warm temperatures in early spring. Monitor growth to kill it at an appropriate time. If it is allowed to grow too tall, rye can deplete soil moisture, and incorporation may be difficult. Rye acts as a host for root-lesion nematode, particularly when grown as a full-season crop.

Winter Wheat

Seed winter wheat from late August through October. It can be seeded outside this time frame, however, weather conditions may reduce top growth. Wheat will survive over winter and begin growing in April. The stand can be killed through tillage or herbicide application. Compared to rye, the plant shuts down earlier in the fall and begins to grow later in the spring.

Cautions: Winter wheat does not generally provide the same amount of green material to return to the soil or the level of weed suppression that rye provides. Early planted wheat may be more susceptible to infection with the barley yellow dwarf virus (BYDV), however this will have little impact to growth of the wheat as a plow down cover crop.

Legumes

Legume cover crops can fix nitrogen from the air. They then supply it to the succeeding crop as well as protecting the soil from erosion and adding organic matter. The amount of nitrogen fixed varies between species. Generally, more top growth equals more nitrogen fixed. Some legume species have aggressive tap roots that can break up subsoil compaction, but this will require more than one season's growth.

Nitrogen release from legumes can be inconsistent. This must be accounted for when calculating your fertilizer needs. Excess nitrogen release late in the season could lead to excessive vegetative growth in fruiting vegetables, such as tomatoes, peppers and melons.

Hairy Vetch

To provide good ground cover over winter, hairy vetch must be seeded by mid-August. It grows slowly until freeze-up, establishing a very vigorous, fibrous root with moderate top growth. Hairy vetch may also be drilled into winter wheat when the wheat is about 20 cm (8 in.) tall. Seeding at this stage prevents the hairy vetch from causing a problem with wheat harvest but results in much

more vetch growth by freeze-up compared to August seedings.

Hairy vetch vines resume growth early in the spring (similar to the time for winter wheat) and may reach 150 cm (5 ft) in length if left to maturity. Cover crop stands are usually killed in the spring by tillage or herbicide application. Vetch's fibrous root system improves soil structure. It also adds large amounts of fresh organic matter to the soil.

Cautions: Competition from volunteer cereals can lead to poor stands of hairy vetch. On droughty soils, hairy vetch left alive until early May may deplete soil moisture. Roundup is not effective in killing hairy vetch; use 2,4-D, MCPA, Banvel or their mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Red Clover

Red clover is commonly broadcast into winter wheat in March or early April or seeded with spring cereals. Early seeding gives best stands. Double-cut red clover is more resistant to dry summer conditions. It produces considerably more top growth than single cut (60 cm (24 in.) vs. 25 cm (10 in.), respectively). For plowdown, common seed produces equal results to pedigreed seed, although it may contain more weed seeds.

The bulk of red clover growth takes place from grain harvest until a heavy frost. Red clover can be killed in the fall or the spring by tillage or herbicide application. Unless herbicides are also applied, chisel plowing will not kill the stand completely.

Red clover plowdown improves soil structure and adds large amounts of organic matter. Nitrogen is fixed and released slowly to the following crop. It gives excellent erosion protection when left unplowed until spring or killed in the fall with a herbicide.

Cautions: Roundup alone is often not effective in killing red clover; consider 2,4-D, MCPA, Banvel or mixtures. If hormone-sensitive crops are following, apply hormone sprays in the fall to avoid injury.

Sweetclover

Sweetclover is most commonly seeded into winter wheat in March or early April or seeded with spring cereals. Either yellow- or white-blossom type may be used. White-blossom type produces somewhat taller top growth.

The bulk of sweet clover growth takes place after the grain is harvested until heavy frosts. Top growth will usually be 30–40 cm (12–16 in.) tall, but not dense. A strong taproot is produced, often 30 cm (12 in.) long and 1 cm (½ in.) across at the crown. If allowed to grow the following spring, sweetclover will flower in July at a height of about 180 cm (6 ft), set seed and die. Plowdown stands may be killed in the fall or the following spring by tillage or with herbicides.

Cautions: Sweetclover is very sensitive to many herbicides and will not tolerate any phenoxy herbicides, including 2,4-D.

Non-Legume Broadleaves

These broadleaf crops cannot fix nitrogen out of the air but they may absorb large quantities from the soil. Neither of these crops are winter-hardy, so additional control measures are not normally required. Do not allow these crops to go to seed, as the volunteer seed can become a significant weed problem.

Buckwheat

As a cover crop, buckwheat is most commonly seeded in late June to early August. It grows very rapidly, reaching flower stage and a height of 45–75 cm (18–30 in.) in about 6 weeks. It has a relatively small fibrous root system and is completely killed by the first frost.

Buckwheat provides rapid soil cover and gives good erosion protection during the growing season. It smothers annual weeds and suppresses perennial ones. Moderate amounts of fresh organic matter are returned to the soil. Buckwheat does not fix nitrogen.

Cautions: Late summer seedings may be killed by an early frost before providing significant growth.

Oilseed Radish

Oilseed radish is commonly seeded in August or very early September. It is unaffected by early frosts. It can grow to a height of 50–90 cm (20–35 in.) and bloom in October. The plant has a thick but short taproot, varying between carrot and turnip shaped. It is killed by severe frosts in late November or December.

Oilseed radish gives a reasonably rapid soil cover and excellent erosion protection over winter. It returns moderate amounts of organic matter to the soil. For good growth, this crop must have a large amount of available nitrogen, either from a recent manure application or leftover from a previous crop.

Some oilseed radish (and certain mustard) cultivars can help to reduce plant parasitic nematode populations in the soil. The nematode-suppressing cultivars must be incorporated into the soil as a "green manure" crop. As the green residue breaks down, it releases a nematode-killing compound (isothiocyanate) into the soil.

Cautions: Growth will be poor if soil nitrogen levels are low or if compaction is severe. Scattered volunteer plants usually appear in most crops planted after oilseed radish. More than 1 year of a nematode-suppressing cover crop may be required to successfully reduce nematode population levels below the economic thresholds.

The mild winters of Southwestern Ontario may allow some varieties of oilseed radish to partially overwinter.

For more detailed information on cover crop use and management, see the OMAF Web site at www.omaf.gov.on.ca.

Tillage Systems After Cover Crops

In conservation and no-till cropping systems, cover crops can greatly increase the surface residue cover, adding to the potential benefits of the system.

Management factors to consider when reduced tillage follows cover crops are:

- Some regrowth of winter annual, biennial or perennial cover crops will occur in the following crop year. Usually this is easily controlled with normal herbicide treatments in the following crop. A controlled amount of regrowth (for example, windstrips) can provide some spring wind protection.
- The first conservation tillage operation with overwintering cover crops should occur at least 2 weeks prior to planting the main crop to allow for the breakdown of the residue to start.
- Seedbed preparation may be difficult if persistent cover crops are not tilled until spring or if they are allowed to grow too large.
- Cover crops that do not survive over winter may be an option, especially on more poorly drained soils or for crops that are planted very early in the spring.
- Burndown herbicides should be considered before conservation tillage of overwintering cover crops such as rye. Careful timing, rate and application of herbicides can help keep enough residue on the surface to prevent wind damage to tender crops while allowing crop establishment.

Water Quality

Water is a valuable resource. A clean and abundant supply of water is critical to the success of the farm business and the health of your family. Others, including fish and wildlife, share our water resources. Growers have a right to expect an ample supply of clean water, and it is their responsibility to ensure that the water leaving the farm is abundant and clean for the next user.

Farm operations impact water quality in many ways. Soil erosion, manures, septic system effluent, milkhouse wastes, fertilizers, pesticides and fuel can affect surface and/or groundwater quality.

Improving Water Quality

The greatest water quality challenges affecting farmers involve bacteria (mostly from manures), nitrates, phosphorus and sediment. Problems can be minimized using the following practices.

Bacterial Contamination

- Contain runoff from manure storages, livestock yards, silos and cull piles.
- Avoid spreading manure on frozen or snow-covered ground.
- Make sure wells are properly maintained and protected from surface contamination.
- Ensure that the domestic septic system is working properly and is not discharging into a drainage system.

Soil Erosion

- Adopt the conservation tillage practices outlined earlier in this chapter.
- Install erosion-control structures.
- Use cover crops and wind-abatement crops.

Nitrate Contamination

- Complete and follow a nutrient management plan for the farm.
- Avoid spreading excessive amounts of manure or fertilizers.
- User cover crops to capture residual nitrogen.
- Where a lot of manure and forages are used, use the nitrate soil test to determine nitrogen requirements.
- Reduce nitrogen fertilizer when the previous crop was a legume or when manure was applied.

The following booklets from OMAF, Agriculture & Agri-Food Canada and the Ontario Federation of Agriculture contain more information on water quality problems and solutions, soil conservation measures and nutrient and manure use:

- *Best Management Practices: Water Management,* Order No. BMP07
- *Best Management Practices: Soil Management,* Order No. BMP06
- *Best Management Practices: Field Crop Production,* Order No. BMP02
- *Best Management Practices: Nutrient Management,* Order No. BMP05
- *Best Management Practices: Pesticide Storage, Handling & Application,* Order No. BMP13
- *Best Management Practices: Water Wells,* Order No. BMP12

To order, contact the Ontario Federation of Agriculture, Attn: Manager, BMP; 40 Eglinton Ave. E., 5th floor, Toronto, ON, M4P 3B1. Phone: (416) 485-3333; Fax: (416) 485-9027; e-mail: ofarsch@flexnet.com. Some information from these publications is also available on the OMAF Web site at www.omaf.gov.on.ca.

4. Vegetable Production Practices

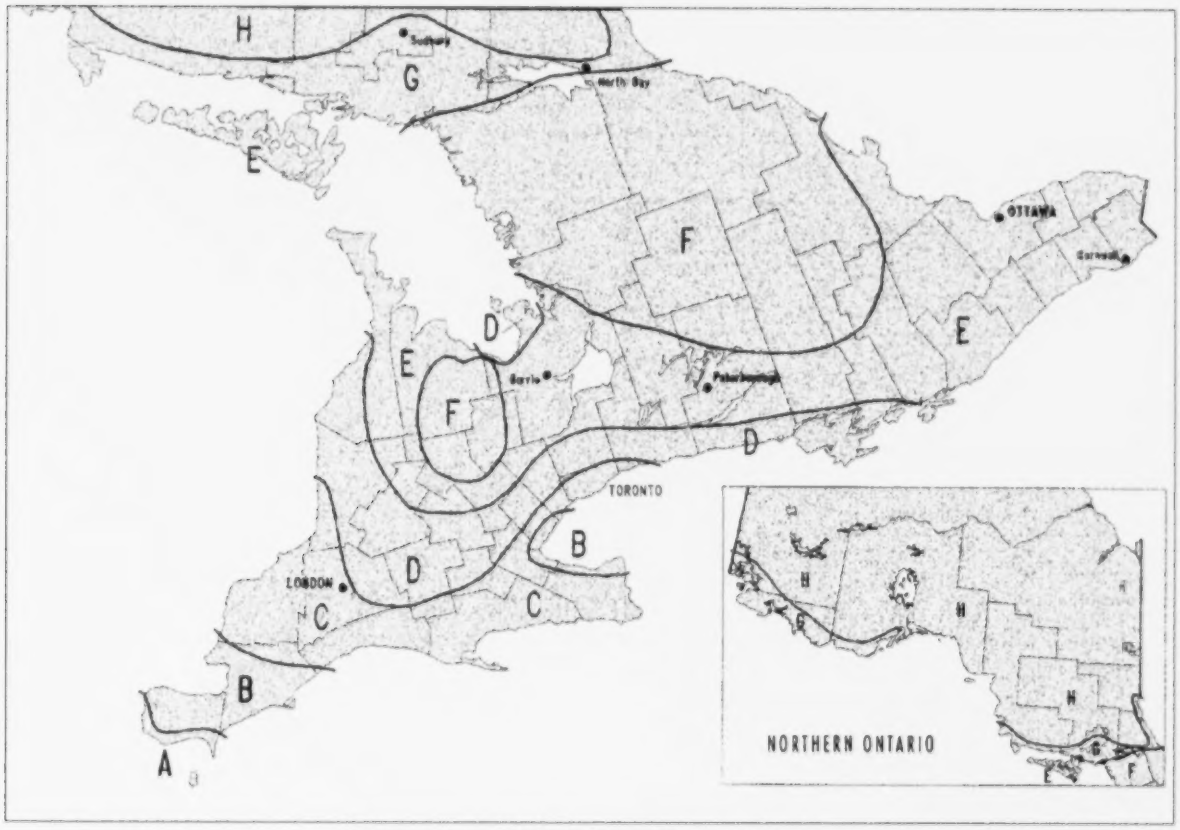

Figure 4–1. Climate Zone Map of Ontario

Climate

Most vegetable production is concentrated in Southern Ontario. There are differences in climate even in this small area, particularly in the length of the growing season and in average temperatures. Vegetable crop development is usually referred to by the number of "days to maturity." This measure indicates the average number of days from planting to harvest maturity. However, due to variability in daily temperatures and light intensity, this measure of "days to maturity" does not always reflect crop growth under actual growing conditions.

Climate Zones and Planting Dates

As shown in Figure 4–1, *Climate Zone Map of Ontario*, above, and Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, right, Zone A, in the Leamington-Harrow-Amherstburg area bordering on Lake Erie, has the longest growing season. The growing seasons of the other zones are progressively shorter. The zone lines in the map are approximate and do not represent sharp

Table 4–1. Average Frost-Free Period in Climatic Zones of Ontario

Zone	Frost-free Period (Average in Days)	Average Date of Last Spring Frost	Average Date of First Fall Frost
A	180	April 25	October 25
B	165–180	May 5	October 15
C	145–165	May 10	October 10
D	130–145	May 18	October 2
E	120–135	May 22	September 28
F	105–120	May 31	September 20
G	100–120	May 25	September 15
H	100 or less	After May 25	Before Sept. 15

Table 4–2.
First Field Seeding or Planting Dates for Commercial Production

Crops	Zone A	Zone C	Zone E
Frost Hardy			
Asparagus, broccoli, Brussels sprouts, cabbages, lettuce, onions (set, seed, Spanish), radishes, rhubarb, peas, spinach, parsnips, early potatoes	April 1–15	April 15–25	April 25–May10
Semi-Frost Hardy			
Beets, carrots, cauliflower, celery, late potatoes, early sweet corn	April 15–25	April 25–May 10	May 5–15
Semi-Frost Tender			
Snap beans, sweet corn, tomatoes	May 1–15	May 15–25	May 25–June 5
Frost Tender			
Lima beans, cucumbers, eggplant, muskmelons, peppers, pumpkins, squash, watermelons	May 20–30	May 25–June 5	June 5–15

changes in climate. The gradation of temperature and growing season from one zone to another is gradual.

Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 37, defines each lettered zone on the map. It gives the average dates of first and last frost (0°C or 32°F) in each zone, based on climate data from 1961 to 1990.

The dates listed in the table indicate that 50% of the time (one year in two) there will be frost in these locations by that date. There is a 25% risk of a frost occurring 7 days after the listed last spring frost date. The risk decreases to 10% 14 days after the listed date. Conversely, there is a similar risk factor associated with frost occurring before the first fall frost dates.

Note that the frost dates in Table 4–1 refer to the occurrences of 0°C (32°F) at a standard height of 1.5 m, at which time tender crops will often be damaged. Frost-hardier crops are not usually damaged until temperatures at this height drop below –2°C (28°F). The date of occurrence of –2°C (28°F) is usually about 2 weeks earlier in the spring or later in the fall than the date of 0°C (32°F). For a list of vegetable crops and their comparative hardiness, see Table 4–2, *First Field Seeding or Planting Dates for Commercial Production*, above.

Table 4–3.
Minimum Soil Temperature Conditions for Vegetable Seed Germination

Vegetable	°F	°C	Vegetable	°F	°C
Asparagus	50	10	Okra	60	16
Bean	60	16	Onion	35	2
Bean, lima	60	16	Parsley	40	4
Beet	40	4	Parsnip	35	2
Cabbage	40	4	Pea	40	4
Carrot	40	4	Pepper	60	16
Cauliflower	40	4	Pumpkin	60	16
Celery	40	4	Radish	40	4
Chard, Swiss	40	4	Spinach	35	2
Corn	50	10	Squash	60	16
Cucumber	60	16	Tomato	50	10
Eggplant	60	16	Turnip	40	4
Lettuce	35	2	Watermelon	60	16
Muskmelon	60	16			

Growing conditions are also influenced by local variations in topography, altitude, natural air drainage and nearness to water. Cold air tends to flow into low-lying areas. Plants at the bottom of a slope are often the first to suffer frost injury. Local variations must be considered in deciding the location and time of planting.

Table 4–2, left, gives approximate first seeding or planting dates for common vegetable crops. Dates are given for Zones A, C and E. Planting dates for the other zones fall between these dates. These dates are only a guide. Take seasonable variations into consideration.

For many crops, the soil temperature is very important for determining the rate of early growth. Delay planting if the soil is still cool, even if the air temperature is high. See Table 4–3, *Minimum Soil Temperature Conditions for Vegetable Seed Germination*, above.

Growing Degree Days

Growing degree days (GDDs) are used to estimate the growth and development of plants and insects during the production season. They tend to be more accurate than "days to maturity."

The development of most crops and insects is closely related to the daily accumulation of heat. A certain amount of heat is required to provide enough energy for the organism to move to the next development stage. For example, it takes 300 GDDs for the first emergence of European corn borer moths to occur in Southwestern Ontario. The heat requirements do not change from year to year. But, depending on

weather conditions, the amount of actual time (calendar days) can vary between years.

Each organism has a minimum base temperature or threshold at which development does not occur. These base temperatures are different for each organism.

To calculate GDD, first determine the mean temperature for the day. This is done by taking the maximum and minimum temperatures for the day, adding them together and dividing by two. The base temperature is then subtracted from the mean temperature to give a daily GDD. If the resultant daily GDD is a negative number, count it as zero. Each daily GDD is then added up (accumulated) over the growing season.

$$\frac{\text{Daily Maximum Temperature} + \text{Daily Minimum Temperature}}{2} - \text{Base} = \text{Growing Degree Days}$$

There are GDD models developed for most vegetable crops. There are four factors to consider when comparing GDD accumulations from various sources or regions.

- Are the base temperatures used in the equations the same? Different organisms have different base temperatures used to calculate growing degree days. 150 GDDs at base 10 does not equal 150 GDDs at base 0.
- Are the start dates for the accumulations the same? Generally, GDD accumulations start on April 1 each year, but some insect GDD models start at the emergence of a specific life stage. This is referred to as a biofix.
- Are the equations used to calculate the daily GDDs the same? Many modifications to the simple GDD calculation have been developed over the years and may be referred to generally as degree days.
- Are the temperatures used in degrees Celsius or Fahrenheit? GDD accumulations will vary significantly, depending whether they are being tracked in Celsius or Fahrenheit. GDD models have been designed specifically for use in Celsius or in Fahrenheit and cannot be interchanged without making conversions.

Confusion has been created over the years by the terminology used to describe growing degree days. In Ontario, the terms growing degree days (GDDs) and crop heat units (CHUs) are used. These terms represent two very different development models. The crop heat units calculation now used in Ontario is identical to the traditional corn heat units calculation. Its name was changed to reflect its now broader application to other crops.

Growing degree days are sometimes referred to as "degree days" or "degree days averaging method." Some jurisdictions use the term "heat units" interchangeably with degree days.

Crop Heat Units (CHU)

While the principles are similar, the equation for a CHU is more complicated than the equation for a GDD. Crop heat units place limits on maximum and minimum temperatures. Like the base temperature used in GDDs, the limits used in CHUs are determined experimentally and are specific to the crop concerned.

$$\text{Daily CHU} = (\text{Ymax} + \text{Ymin}) \div 2$$

$$\text{Ymax} = [3.33 \times (\text{Tmax} - 10)] - [0.084 \times (\text{Tmax} - 10)^2]$$

$$\text{Ymin} = [1.8 \times (\text{Tmin} - 4.4)]$$

- If values are negative, set to 0.
- Tmax and Tmin = Daily maximum or minimum air temperature in degrees Celsius, usually measured from midnight to midnight.

The calculations for daily minimum and daily maximum temperatures account for important factors in the growth of warm season crops. Warm-season crops such as corn do not grow below 10°C (50°F). Corn and other warm-season crops grow faster as the temperature increases up to 30°C (86°F). Above 30°C (86°F), growth of even warm-season crops slows.

> For more information on crop heat units, refer to the OMAF Factsheet, *Crop Heat Units for Corn and Other Warm-Season Crops in Ontario*, Order No. 93-119.

Seeding Practices

Seed

Use only high-quality seed, which is certified disease-free and treated to eliminate or protect against insects and diseases. Registered seed treatments are listed in the individual crop sections in Chapter 6, *Crop Management Recommendations*, starting on page 61.

Saving your own seed is **not** recommended. Saved seed has a high potential for disease contamination, and hybrid cultivars will not grow true to type. For certain popular varieties, seed should be ordered as much as 1 year in advance to ensure availability.

Pelletized and Primed Seed

Pelletized seed has been coated to make it larger or more uniform. Onion, carrot and lettuce seed tends to be irreg-

Table 4–4.
Vegetable Seed Life Expectancy

1 to 2 Years	3 to 4 Years		5+ Years
Corn	Asparagus	Fennel	Cucumbers
Leeks	Beans	Kale	Endive
Okra	Beets	Mustard	Lettuce
Onions	Broccoli	Peas	Muskmelons
Parsley	Brussels sprouts	Pumpkins	Radishes
Parsnips	Cabbages	Rutabagas	
Peppers	Carrots	Spinach	
Rhubarb	Cauliflower	Squash	
	Celery	Tomatoes	
	Chinese cabbage	Turnips	
	Eggplant	Watermelons	

ularly shaped or small. Pelletized seed makes the mechanical planting of these crops much easier.

Primed seed has been partially hydrated, then dried down. This treatment results in earlier germination and better uniformity, especially for hard-to-germinate seeds.

Germination, Vigour and Seed Storage

Germination and vigour of all seed declines over time. Seed storage temperatures of 5°C–10°C (40°F–50°F) and 40%– 50% relative humidity are ideal. Excessively low humidity may result in poor germination rates. High humidity will increase the likelihood of fungal contamination.

Seed should be stored in waterproof, vapourproof containers. Life expectancy, even under good storage conditions, varies between different types of vegetable seed. See Table 4–4, *Vegetable Seed Life Expectancy*, left.

Keep in mind that seed vigour declines more rapidly than germination. If seed is past its prime, it may still germinate, but the seedlings will be weaker and more prone to disease.

Plant Populations

Each crop should be spaced according to its optimum needs. The distance between rows will be also determined by the method used to harvest the crop. Specific spacing recommendations can be found in the individual commodity sections in Chapter 6, starting on page 61.

For average plant populations at various row spacings, see Table 4–5, *Plant Populations at Various Planting Distances*, below.

Table 4–5.
Plant Populations at Various Planting Distances

	per Acre									
Row Spacing	Distance within the Row (in)									
(in)	4	6	12	18	24	30	36	48	60	96
12	132,000	87,120	43,560							
18	88,000	58,080	29,040	19,360						
24	66,000	43,560	21,780	14,520	10,890					
30	52,324	34,848	17,424	11,616	8,712	6,969				
36	43,560	29,040	14,520	9,680	7,260	5,808	4,840			
44	39,600	23,803	12,100	8,066	6,050	4,840	4,033	3,025		
48	33,507	21,780	10,890	7,260	5,445	4,356	3,630	2,722		
60			8,712	5,808	4,356	3,484	2,904	2,178	1,742	
96			5,445	3,630	2,722	2,178	1,815	1,361	1,089	680
120					2,178	1,742	1,452	1,089	871	544
	per Hectare									
Row Spacing	**Distance within the Row (cm)**									
(cm)	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**120**	**150**	**240**
30	326,040	251,186	107,593							
45	217,360	143,457	71,728	47,819						
60	163,020	107,593	53,796	35,864	26,898					
75	129,240	86,074	43,037	28,691	21,518	17,213				
90	107,593	71,728	35,864	23,909	17,932	14,345	11,954			
110	97,812	58,793	29,887	19,923	14,943	11,954	9,961	7,471		
120	82,762	53,796	26,898	17,932	13,449	10,759	8,966	6,723		
150			21,518	14,345	10,759	8,605	7,172	5,379	4,302	
240			13,449	8,966	6,723	5,379	4,483	3,361	2,689	1,679
300					5,379	4,302	3,586	2,689	2,151	1,343

Table 4–6.
Row Length per Acre or per Hectare at Various Row Spacings

Distance Between Rows		Length of Row	
Imperial	Metric	Feet of Row/ Acre	Metres of Row/ Hectare
6 in.	15.24 cm	87,120	65,606
12 in.	30.48 cm	43,560	32,802
18 in.	45.72 cm	29,040	21,868
20 in.	50.80 cm	26,136	19,682
24 in.	61.96 cm	21,780	16,401
30 in.	76.20 cm	17,424	13,121
36 in.	91.44 cm	14,520	10,934
40 in.	1.016 m	13,068	9,840
42 in.	1.067 m	12,445	9,372
48 in.	1.219 m	10,890	8,200
60 in.	1.524 m	8,712	6,561
72 in.	1.829 m	7,260	5,467
84 in.	2.134 m	6,223	4,686
96 in.	2.438 m	5,445	4,100
108 in.	2.743 m	4,840	3,645
120 in.	3.048 m	4,356	3,280

Table 4–6, *Row Length per Acre or per Hectare at Various Row Spacings*, above, shows the row length per acre (or hectare) at various row spacings. Table 4–7, *Approximate Planting Depth and Seeds per Gram*, right, outlines the approximate planting depth and number seeds per gram for each vegetable crop.

Plasticulture

Many vegetable crops, especially heat-loving crops such as cucurbits (vine crops), peppers, tomatoes, eggplant and sweet corn, benefit from the use of plastic mulch and row covers (plasticulture). Some benefits associated with plasticulture include:

- earlier harvest
- increased yield
- higher quality produce
- soil moisture retention
- reduced disease pressure due to minimal soil/plant contact
- reduced fertilizer leaching
- increased season long nutrient availability
- weed control

While plasticulture may be used with conventional fertilization and irrigation practices, consider using drip (trickle) irrigation with fertilizer injection (fertigation) to maximize yield and quality. See the sections *Irrigation*, on page 44, and *Fertigation*, on page 46, for more information.

Table 4–7.
Approximate Planting Depth and Seeds per Gram

Crop	Seeds per Gram	Seed Planting Depth (mm)	Seed Planting Depth (in)
Asparagus	50	25	1
Beans, snap	2–3	40	1½
Beans, lima	1–3	40	1½
Beets, Swiss chard	50	15	½
Broccoli	320	5	¼
Brussels sprouts	280	5	¼
Cabbages	300	5	¼
Chinese cabbage	250	5	¼
Carrots	900	5	¼
Cauliflower	350	5	¼
Celery, celeriac	1,800	3	⅛
Chicory	600	5	¼
Collard	280	5	¼
Corn	4–8	25–65	1–2½
Cucumbers	40	20	¾
Eggplant	200	15	½
Endive	500	5	¼
Kale	270	5	¼
Kohlrabi	280	5	¼
Leeks	350	15	½
Lettuce	700	5	¼
Melons	40	25	1
Mustard	550	5	¼
Onions	280	15	½
Parsley	550	5	¼
Parsnips	200	15	½
Peas	3–6	25	1
Peppers	150	5	¼
Pumpkins	4	25	1
Radishes	125	15	½
Rutabagas	280	5	¼
Spinach	90	20	¾
Squash	10	25	1
Tomatoes	350	5	¼
Watermelons	10	25	1

Plastic Mulch

Most mulches are made of polyethylene. Table 4–8, *Plastic Mulch Types*, on page 42, describes the different types. They are available in widths of 1.2–1.5 m (4–5 ft) with a thickness of 1–1.5 mil (millionths of an inch). Mulches are also available in smooth and embossed. Smooth plastic has better stretch during laying, allowing for a tighter

Table 4–8.
Plastic Mulch Types

Type	Average Soil Warming at 2" depth	Advantages	Disadvantages
Black	2°C–4°C (37°F–39°F)	Prevents weed seed germination.	Good soil-to-plastic contact is necessary to ensure maximum heat transfer.
Clear	4°C–8°C (39°F–46°F)	Can be used with direct-seeded crops such as sweet corn.	Weed germination under the mulch requires good pre-plant (residual) weed control.
Infra-red transmitting (IRT)	6°C (43°F)	Absorbs certain wavelenghts of light, preventing weed seed germination and growth.	Expensive. Tomato and pepper yields may be lower on IRT mulches than on black.
Photo-degradable	Same as undegradable mulch	Breaks down with exposure to sunlight, eliminating the need for retrieval and disposal at the end of the season.	Rate of breakdown can be inconsistent. Buried edges frequently do not break down, leaving plastic residue in the field. These plastic residues are often difficult to retrieve.
Biodegradable	Same as undegradable mulch	Usually a starch-based plastic. Broken down by soil micro-organisims.	Most of these mulches are relatively new in the marketplace, and only limited quantities are available. There is a big range in the quality and degradability of products. Always field test new products on a limited scale first.

fit to the bed, initially. However, embossed plastic suffers less from expansion and contraction, allowing the plastic to better conform to the soil bed throughout the growing season.

Several commercial plastic mulch layers are available. Proper set-up of the mulch layer is essential. The edges of the mulch should be well covered, and the plastic should be tight on the soil surface to permit heat transfer to the soil. Angle the discs and press wheels of the mulch layer to ensure a tight and uniform fit.

Mulch should not be laid on dry soil. If the soil is very dry, irrigate or wait for rainfall before laying. Soil moisture is important for heat retention. Lay mulch 2–3 weeks prior to planting for maximum soil heating.

Row Covers

Row covers can be used to promote earlier production by increasing the canopy air temperature and protecting young transplants from wind damage. There are two basic types, floating row covers and low tunnels.

Regardless of the type of row cover used, heat can build up inside the covers and damage crops. Temperatures should be monitored, and the covers removed or ventilated when the temperature exceeds 32°C–35°C (90°F–95°F). For crops that require bee pollination (vine crops), row covers must be removed or opened up at flowering time.

Floating Covers

These are made of polypropylene or various polyester-type fabrics and are laid directly over the crop. They are available in sheets up to 15 m (50 ft) wide to cover multiple rows. Floating covers are well suited for large acreages and low-growing plants. They are not recommended for use on upright-growing crops such as tomatoes and peppers, because they can cause abrasions on the plant's shoot tips.

Low Tunnels

These are made of white or clear polyethylene and are supported over the crop on wire hoops. The plastic usually has slits or perforations for ventilation. Commercially available layers install hoops, lay the plastic covers over the hoops and bury the edges of the row cover in one operation.

Research in Ontario has demonstrated that use of low tunnels can result in earlier production of lettuce, peppers, cucumbers and melons. Tunnels used on fresh-market tomatoes should be removed well before flowering. Extended use of row covers on tomatoes may result in reduced fruit set.

Plastic Disposal

Used plastic mulches are difficult to recycle due to the amount of dirt, plant material and water present. Limited recycling opportunities do exist in some areas. In most areas, disposal at a licensed landfill site is currently the most practical option. Burning or on-farm burial is **not** recommended.

Spraying Vegetable Crops

Water Volume and Pressure

Generally, most insecticides/fungicides are applied with about 135–450 L/ha (54–180 L/ac). Herbicide applications range from 55–350 L/ha (22–140 L/ac).

For fungicides and insecticides, pressures of between 550–1,000 kPa and hollow cone-type nozzles are commonly used. For herbicide applications, spray pressures range from 200–500 kPa for standard flat fan nozzles. To reduce the potential for drift, manufacturers offer drift-reducing tips that deliver the same amount of spray as conventional nozzles but produce a coarser droplet spectrum.

Nozzle Selection

Flat fan nozzles provide uniform spray distribution across the whole boom. They are best used with boom-type sprayers for herbicide applications.

Hollow cone nozzles are generally used to apply fungicides or insecticides. This type of nozzle produces a finer and more uniform spray distribution than solid cone nozzles. Hollow cone nozzles are particularly suited to the application of wettable powders, flowables and suspensions.

Solid cone nozzles are used when increased penetration into the crop canopy is required.

Air Temperature and Relative Humidity

Pesticides, especially insecticides, can cause phytotoxicity or burning of plant foliage or flowers if applied during very hot weather (above 27°C or 81°F). In hot conditions, avoid applications between 10:00 AM and 2:00 PM, as plants will be more prone to injury. The water droplets themselves can, at times, act as tiny magnifying lenses causing plant injury. A large portion of the spray droplets may also evaporate in hot, dry conditions before they hit the target.

During conditions of high relative humidity, the drying of the spray materials will be delayed. Slow and prolonged drying of pesticides can lead to phytotoxicity in some instances.

Also note that "synthetic pyrethroid"–type insecticides (Ripcord, Decis, Pounce, Matador, etc.) break down quickly when air temperatures are above 27°C (81°F), reducing their effectiveness. If possible, apply these in the evening, when temperatures have dropped, or select a different product.

Rainfall

The decision to spray just prior to a rain or shortly after should be based on plant protection. This may be more critical when applying fungicides. Waiting for the rain to stop before the initial application may allow disease organisms to invade unprotected plant tissue. Once they have dried, most fungicides can withstand about 2.5 cm (1 in.) of rainfall and still provide adequate protection.

Many preemergent herbicides are best applied before a rain. Moist soils allow for better distribution of the herbicide within the seed zone. Post emergent applications are best applied after a rain or should be timed to allow to adequate drying prior to rainfall.

Wind Speed & Drift

When applying fungicides and insecticides, moderate air movement helps move the product in and around the crop. In addition, light winds will help in the drying process.Optimum air movement is 3–8 km/h.

To prevent unwanted drift, avoid spraying when the wind speed is more than 11 km/h. Drift is also possible at lower wind speeds and no-wind conditions. Drift potential is affected by the interaction of travel speed, wind speed and droplet size.

Spray droplets can drift for up to 6 km. Plants such as grapes, beans, peppers and tomatoes are particularly sensitive to dicamba, glyphosate and 2,4-D injury. When applying herbicides, drift can be minimized by:

- using larger droplet sizes
- not applying during very hot and dry weather (temperatures in excess of 27°C or 81°F) when spray material can readily volatilize
- avoiding still-air conditions or when winds cause off-target droplet movement

For more information on drift reduction, see the section *Reduce Pesticide Spray Drift*, on page 7.

Field Boom-Type Sprayer Calibration

These five steps will help you calibrate your boom sprayer application rates in L/ha.

Instructions

1. Measure the time.
   - Place 2 stakes 50 m apart in the field.
   - Select the gear and throttle setting (rpm) at which you plan to spray.
   - Half-fill the sprayer with water.

- Drive the distance between the stakes three times, timing each pass. Each time, make sure the tractor is at the desired speed as you pass the first stake and maintain this speed until you pass the second stake.
- Note the average time of the 3 passes.

2. Measure the average nozzle output.
- Park the sprayer with the PTO engaged and the throttle adjusted to reach the PTO speed set in the test run.
- Adjust the pressure regulator to the desired working pressure with full flow to the boom.
- Collect the output from each nozzle for the average length of time needed to travel the 50 m in the test run.
- Enter the nozzle outputs into the equation below.

3. Measure the nozzle spacing in metres.

4. Use the following formula to determine the sprayer output:

$$\text{Sprayer Output (L/ha)} = \frac{\text{Average Nozzle Output (mL)}}{\text{Nozzle spacing (m)}} \times 0.2$$

5. Clean or replace any nozzle more than 5% above or below the average output. Calculate the actual area sprayed after each tank of spray solution is applied. Re-check the sprayer calibration after each tank of spray is applied by dividing the volume sprayed by the area sprayed. The nature of some products may slightly alter the calibration from that of clean water.

To measure in litres/acre or gallons/acre, use the following conversion guide.

Litres/ha x 0.4 = L/ac
Litres/ha x 0.09 = Imp. gal/ac
Litres/ha x 0.11 = U.S. gal/ac

Sample Calculation

1. Average time to travel 50 m (164 ft)	=	24.5 sec
2. Average amount of liquid collected per nozzle for 24.5 sec	=	525 mL
3. Nozzle spacing on the boom	=	0.5 m (~20 in.)
4. Application rate $= \frac{525 \text{ mL} \times 0.2}{0.5 \text{ m}}$	=	210 L/ha

Conversion

210 L/ha x 0.4	=	84 L/ac
210 L/ha x 0.09	=	18.9 Imp. gal/ac
210 L/ha x 0.11	=	23 U.S. gal/ac

Irrigation

Most vegetable crops require a uniform supply of moisture throughout the growing season. The average rainfall in Ontario is 70 mm (3 in.)/month during the growing season. For most vegetable crops, this provides only 65% of the water needed for optimum yield.

Note: You must have a Permit to Take Water issued by the Ministry of the Environment to use more than 50,000 L of water in a day from either surface or groundwater sources for irrigation.

Crops, Soils and Water Demand

Soil types differ in their ability to retain water following rainfall or irrigation. Water that is held by the soil and can be taken up by plants is called "available soil moisture" (ASM). The irrigation point occurs when the ASM is depleted to 50%. Beyond 50% of ASM, crop yield and quality may be affected.

Sands and coarse sandy loams retain approximately 50 mm (2 in.) of ASM in the top 60 cm (24 in.) of the soil. Under average conditions, a crop will use half this moisture in 7 days. On these soils, a weekly irrigation of 25 mm (1 in.) of water, or 50% of the ASM, would be required to maintain high yields.

Fine sandy loams and silty loams retain 70–110 mm (2.8–4.3 in.) of ASM in the top 60 cm (24 in.). On these soils, heavier and less frequent irrigation, approximately 35–50 mm (1.5–2.4 in.) of water every 10–14 days, are required for optimum yields.

During the hot part of the growing season, irrigation applications should become more frequent. Likewise, during the cool part of the growing season, irrigation applications are required less often.

Application of unnecessarily high amounts of irrigation wastes water and can cause leaching of fertilizers and pesticides. Water must be applied slowly to avoid runoff. The water application rate must not exceed the infiltration rate.

The infiltration rate of a soil is measured by its hydraulic conductivity when it is at field capacity (fully saturated.) See Table 4–9, *Permeability Classification and Saturated Hydraulic Conductivity Values for Soil Textural Classes*, on page 45, for approximate infiltration rates based on soil type. An infiltration rate within the appropriate range is also a good measure of soil quality.

Table 4–9.
Permeability Classification and Saturated Hydraulic Conductivity Values for Soil Textural Classes

Textural Classes	Permeability Class	Saturated Hydraulic Conductivity	
		cm/sec	in/hr
Gravels, coarse sands	rapid	$> 4.4 \times 10^{-3}$	> 6.3
Loamy sands and sandy loams	moderately rapid	$1.4 - 4.4 \times 10^{-3}$	2.0–6.3
Fine sandy loams, loams	moderately rapid	$0.4 - 1.4 \times 10^{-3}$	0.56–2.0
Loams, silt loams, clay loams	moderately rapid	$0.14 - 0.4 \times 10^{-3}$	0.2–0.56
Clay loams, clays	slow	$4 - 14 \times 10^{-5}$	0.056–0.2
Dense, compacted clays	very slow	$< 4 \times 10^{-5}$	< 0.056

Different vegetable crops also vary in their response to irrigation. Shallow-rooted crops such as potatoes and celery require frequent, light irrigations. Deep-rooted crops can use water from a greater volume of the soil profile and do not require irrigation as frequently. Table 4–10, *Classification of Vegetable Crops by Rooting Depth*, right, shows the relative rooting depths of a number of vegetable crops.

In addition, most vegetable crops have growth stages during which drought stress can severely reduce yield and quality. Irrigation is especially important during these critical growth periods, listed in Table 4–11, *Critical Periods for Irrigation of Several Vegetable Crops*, right.

Irrigation Systems

A number of different types of irrigation systems have been adapted for use in vegetable crops.

Hand-Moved Sprinklers

For small operations (<50 acres), this is the least expensive type of overhead irrigation equipment. The labour costs to move the laterals through the field is relatively high. Water distribution is very uniform, although tall crops are not easily irrigated unless riser pipes are used. Sprinkler irrigation may also be used for frost protection.

Travelling-Gun Systems

These systems are relatively inexpensive. Labour cost is less, compared to hand-moved sprinklers. They are well suited to irrigating tall crops, as well as large and/or unusually shaped fields. Uniformity of water distribution is greatly affected by placement and wind conditions.

Centre-Pivot and Lateral Systems

These are self-propelled systems located to move through and irrigate large fields from a central location. These systems are relatively expensive. They are best adapted for use in relatively level fields. Labour costs through the season are very low. New micro pivots are suitable for a range of field sizes from small to large.

Table 4–10.
Classification of Vegetable Crops by Rooting Depth

Shallow-Rooted (down to 30 cm)	Intermediate (30–60 cm depth)	Deep-Rooted (deeper than 60 cm)
broccoli	beans, snap	asparagus
cabbages	carrots	parsnips
cauliflower	muskmelons	pumpkins
celery	peppers	sweet corn
cucumbers	tomatoes	watermelons
lettuce	zucchini	winter squash
onions		
potatoes		
radishes		

Drip (Trickle) Irrigation

Drip irrigation systems consist of a series of drip lines (plastic tubing with built-in emitters) laid along the crop rows. Crop yields are more uniform, and may be slightly higher than with overhead irrigation. If fertilizer injection is combined with drip irrigation, greater yield increases are possible (see the section *Fertigation*, on page 46.)

The cost of installing a drip system is relatively high. However, the labour costs through the season are very low. A major advantage of drip systems is that less water is required. Drip irrigation provides the crop with a uniform supply of water through the season.

A drip irrigation system consists of a filtration system, flow meter, pressure regulator, main line, header lines

Table 4–11.
Critical Periods for Irrigation of Several Vegetable Crops

Critical Period	Crop
Flowering, pod setting	snap beans
Head formation and enlargement	broccoli
	cabbages
	cauliflower
Tasseling, pollination, ear filling	sweet corn
Flowering, fruit set and development	cucumbers
	muskmelons
	watermelons
	zucchini
Bulb formation and enlargement	onions
Flowering, fruit set and enlargement	eggplant
	peppers
	tomatoes

and lateral lines with built-in emitters (drip tubing or tape). A fertilizer injector is also required for fertigation.

Growers should consult with a specialist at an irrigation company for information on designing a drip irrigation system.

Irrigation Scheduling

Whichever type of irrigation system is used, it is important to use some method of irrigation scheduling to avoid drought stress and provide water when it is most needed. There are two basic methods of irrigation scheduling.

Water Budget Method

This method uses climatic data to estimate the amount of available water lost from the rooting zone through crop use and evaporation. The amount of crop water use is calculated using the percentage of crop cover and the evapotranspiration rate from climatic data.

Measuring Soil Moisture

There are several tools available for measuring soil moisture content.

Tensiometers measure how strongly water is being held by the soil. As the soil dries out, moisture is more strongly held to soil particles and less available to the crop. Tensiometers can be used to determine when moisture stress occurs, and thus when irrigation should be started. Sandy soils are irrigated when soil moisture tension reaches 15–20 centibars. Irrigate loamy soils at 20–25 centibars. These units require proper installation and regular maintenance. Accuracy may be reduced on soils with high clay content.

Electrical Resistance Blocks also measure soil water tension in centibars. Compared to tensiometers, they are easier to install. The portable meter and low cost of the units is more conducive to reading soil moisture at several different sites.

Time Domain Reflectometry (TDR) is a more costly tool for soil water monitoring. It is portable and quick. Some units require calibration and may be finicky to work with. Accuracy may be reduced on soils heavier than a clay-loam.

For more irrigation information, refer to:

- OMAF Factsheet *How to Prepare for Irrigation During Water Shortages*, Order No. 99-023
- *Irrigation Scheduling for Tomatoes – Water Budget Approach*, Order No. 90-049

Table 4–12.
Nitrogen and Potash Injection Schedules

Growth Stage	Rate of N and K_2O to Inject Per Week kg/ha (kg/ac)		
	Vine Crops[1]	Peppers	Tomatoes
Transplanting to fruit set	5 (4.5)	3–5 (2.8–4.5)	2.5 (2.2)
Fruit sizing to harvest	10 (9)	7–10 (6.2–9)	5 (4.5)
Harvest	5 (4.5)	3–5 (2.8–4.5)	2.5 (2.2)

[1] Cucumbers, melons, summer squash.

Fertigation

Fertigation is a method of applying water and nutrients through a drip irrigation system. It can be used to increase the yield and quality of many vegetable crops.

A stock solution of soluble (greenhouse grade) fertilizer is dissolved in a tank and introduced through a valve into the irrigation system either by suction or pressure. The fertilizer solution should be fed through the system slowly. After the fertilizer has passed through the system, continue to irrigate to flush the system.

DO NOT mix fertilizers containing calcium, phosphate or sulphates, as these can precipitate out and plug emitters.

Broadcast all of the phosphate requirement and approximately 30%–50% of the nitrogen and potash requirement prior to planting. The remainder should be injected through the drip irrigation system. Use soil tests to determine phosphate and potash requirements. Table 4–12, *Nitrogen and Potash Injection Schedules*, above, outlines recommended application rates for tomatoes, peppers and vine crops.

Food Safety

Food safety hazards include physical, chemical or biological substances that can cause produce to become an unacceptable health risk to consumers.

Physical hazards:	Foreign objects (i.e., wood, plastic, glass) from the environment or from equipment
Chemical hazards:	Pesticide or other contaminants
Biological hazards:	Micro-organisms such as bacteria, viruses, parasites, moulds

Contamination of produce at the farm level can occur directly or indirectly. Produce may become directly contaminated by food safety hazards on the farm or indi-

rectly through contaminated soil, water, etc. Growers can minimize the risk of contamination by being aware of the hazards, identifying potential sources of contamination and using best management practices. Periodically review all farm practices with food safety in mind.

Many growers already incorporate the good agricultural practices presented below. However, this is difficult to verify without documentation. Good records of on-farm food safety practices are useful in today's marketplace.

Preventing Biological Hazards

Potential sources of contamination include:

- untreated (raw) manure used as fertilizer
- contaminated soil, water or feces (from rodents, domestic animals, birds, wildlife, etc.)
- containers or equipment that have not been cleaned adequately
- infectious workers

Good Agricultural Practices

Good agricultural practices can help minimize the risks from these biological hazards.

Field History: Fields on which livestock have recently grazed or where biosolids (sewage sludge) have been applied are most likely to have pathogenic bacteria. Note: biosolids may **not** be applied to vegetable-producing land within 12 months of harvest.

Birds: Discourage the roosting of birds above packing, handling and storage areas.

Manure: Use composted or well-aged manure to reduce microbe levels. Maximize the period between manure application and crop harvest. Incorporate manure into the soil before planting. Do not apply manure after planting where direct or indirect contact may occur with the edible crop part. Locate manure piles away from vegetable crops and packing areas to avoid contamination from wind drift or runoff.

Water: Make sure water quality is appropriate for the use. Use potable water for handwashing, produce washing and hydrocooling. Consider testing irrigation water for bacterial levels. Surface water sources require more frequent testing than groundwater. Consider installing drip irrigation systems, especially for produce that is eaten uncooked.

Storage: Rapid cooling after harvest will help maintain the quality of some vegetables. Keep coolers and storage areas clean (see the section *Storage Sanitation*, on page 49).

Worker Hygiene: Ensure toilets have handwashing stations that are clean, stocked and readily accessible. Teach workers the importance of hygiene practices.

For more information, refer to these Web sites:

Ontario Ministry of Agriculture and Food: www.omaf.gov.on.ca

Canadian Water; Quality Guidelines for Agricultural Water: www.ccme.ca/assets/pdf/e1_06.pdf

CHC guidelines: www.hortcouncil.ca/offs.htm

Canadian Food Inspection Agency: Code of Practice for Minimally Processed Ready-to-Eat Vegetables: www.inspection.gc.ca/english/plaveg/fresh/read-eat_e.shtml

CFIA Traceback Investigation Guidelines for Fresh Fruit & Vegetables: www.inspection.gc.ca/english/plaveg/fresh/traretinvenqe.shtml

Storage

Storage Tips

- Thermometers are not expensive. Have several in the storage area to help ensure the area is being uniformly cooled. Calibrate thermometers regularly to ensure that fresh produce is stored properly. Thermometers set into ice water should read 0°C (32°F).
- Change the wash water daily when washing fresh produce. This prevents the build-up of bacteria. Fresh produce infected with bacteria will break down readily in storage even under cool conditions. Use chlorine at 150-200 ppm to help prevent rot from getting started.
- The quality of the produce coming out of storage will reflect its quality going in.

To preserve the quality of harvested vegetables and improve the marketing of crops, proper storage immediately after harvest is necessary. Rapid, uniform cooling to remove field heat, followed by storing under proper conditions will ensure that a quality product reaches the consumer or processor.

Storage Life for Fresh Vegetables

See Table 4–13, *Storage Life for Fresh Vegetables in Commercial Storage*, on page 48, for recommended storage conditions for individual crops.

Table 4–13.
Storage Life for Fresh Vegetables in Commercial Storage

Commodity	Temperature °C	Temperature °F	Relative Humidity (%)	Approximate Storage Life	Commodity	Temperature °C	Temperature °F	Relative Humidity (%)	Approximate Storage Life
Asparagus	0–2	0–37	95–100	2–3 weeks	Melons				
Beans, green or snap	4–7	39–45	95	7–10 days	Honey Dew	7	45	90–95	3 weeks
Beans, lima	3–5	37–40	95	5–7 days	Muskmelons (¾-slip)	2–5	37–40	95	15 days
Beets, topped	0	32	98–100	4–6 months	Muskmelons (full slip)	0–2	0–37	95	5–14 days
Broccoli	0	32	95–100	10–14 days	Watermelons	10–15	50–59	90	2–3 weeks
Brussels sprouts	0	32	95–100	3–5 weeks	Mushrooms	0	32	95	3–4 days
Cabbage, Chinese	0	32	95–100	2–3 months	Okra	7–10	45–50	90–95	7–10 days
Cabbages, early	0	32	98–100	3–6 weeks	Onions, dry	0	32	65–70	1–8 months
Cabbages, late	0	32	98–100	5–11 months	Onions, green	0	32	95–100	3–4 weeks
Carrots, bunched	0	32	95–100	2 weeks	Onions, sets	0	32	65–70	6–8 months
Carrots, immature	0	32	98–100	4–6 weeks	Parsley	0	32	95–100	2–2.5 months
Carrots, mature	0	32	98–100	7–9 months	Parsnips	0	32	98–100	4–6 months
Cauliflower	0	32	95–98	3–4 weeks	Peas, green	0	32	95–98	1–2 weeks
Celeriac	0	32	97–99	6–8 months	Peppers, chili (dry)	0–10	32–50	60–70	6 months
Celery	0	32	98–100	2–3 months	Peppers, sweet	7–13	45–55	90–95	2–3 weeks
Chard	0	32	95–100	10–14 days	Potatoes, chipping	10	50	90–95	10 months
Chicory, witloof	0	32	95–100	2–4 weeks	Potatoes, early crop	4	39	90–95	7 days
Collards	0	32	95–100	10–14 days	Potatoes, late crop	4	39	90–95	5–10 months
Corn, sweet	0	32	95–98	5–8 days	Potatoes, seed	2–4	37–39	90–95	7 months
Cucumbers	10–13	50–55	95	10–14 days	Potatoes, sweet	13–16	55–61	85–90	4–7 months
Eggplants	8–12	46–54	90–95	1 week	Pumpkins	10–15	50–59	50–70	2–3 months
Endive and escarole	0	32	95–100	2–3 weeks	Radishes	0	32	95–100	3–4 weeks
Garlic	0	32	65–70	6–7 months	Rhubarb	0	32	95–100	2–4 weeks
Greens, leafy[1]	0	32	95–100	10–14 days	Rutabagas	0	32	98–100	4–6 months
Horseradish	–1 0–0	30–32	98–100	10–12 months	Salsify	0	32	95–98	2–4 months
Kale	0	32	95–100	2–3 weeks	Spinach	0	32	95–100	10–14 days
Kohlrabi	0	32	98–100	2–3 months	Squashes, summer	5–10	40–50	95	1–2 weeks
Leeks	0	32	95–100	3–6 months	Squashes, winter	10–15	50–59	50–70	1–6 months
Lettuce	0	32	98–100	2–3 weeks	Sweet potatoes	13–16	55–61	85–90	4–7 months
					Tomatoes, firm-ripe	8–10	46–50	90–95	4–7 days
					Tomatoes, mature-green	13–21	55–70	90–95	1–3 weeks
					Turnips	0	32	95	4–5 months

[1] Leafy greens may be stored for 2–3 weeks if they have been hydo-cooled immediately after harvest.

Ethylene

Ethylene is naturally produced by most fruit and vegetables once harvested and put into storage. It acts as a growth regulator and a ripening agent. Ethephon is a commercially available, synthetically produced ethylene product. It is widely used in the processing tomato industry (see the section *Chemical Fruit Ripening*, on page 173).

Ethylene gas increases the rate of ripening of mature fruits and vegetables, and shortens shelf life. The effects of ethylene gas depend upon:

- the stage of produce maturity
- the temperature and relative humidity of the storage room
- the concentration of ethylene
- the exposure time

Ethylene is an invisible and odourless gas, however, its detrimental effects on produce can be easily misdiagnosed. Some of the undesirable effects of ethylene are:

- loss of green colour in some immature fruits (e.g., cucumbers and summer squash) and leafy vegetables
- accelerated ripening of fruits during handling and storage
- russet spotting on lettuce
- bitterness (isocourmarin) in carrots
- sprouting of potatoes
- abscission of leaves (e.g., cauliflower, cabbage)
- toughening of asparagus

There are many sources of ethylene in the environment. The more important ones include internal combustion engines and ripening produce. Other sources include fluorescent ballasts, decomposing produce, cigarette smoke and rubber materials exposed to heat or UV light.

Use electric rather than gas-powered fork lifts where commodities are sensitive to ethylene. Isolate internal combustion engines from handling and storage areas. Do not let engines idle in an enclosed loading space.

Simple ventilation of handling areas can prevent ethylene build-up, as long as the incoming air is not polluted. One complete air exchange per hour is usually sufficient.

Ethylene can be used to your advantage when controlled and careful ripening of fruits and vegetables is desired. In this case, commercially available ethylene generators are used.

Chilling Injury

Chilling injury occurs when a commodity is exposed to temperatures below its ideal storage range. The minimum storage temperature for each crop varies, as do the symptoms of chilling injury.

Chilling injury is not always easily recognized at the farm gate. Chilled produce often looks fine as it is removed from storage. However, as the temperature increases (in the grocery store, or after purchase) symptoms begin to develop, and quality is quickly compromised.

Chilling injury may occur at any stage of the production and distribution line. The longer the chilling event, the more significant the level of injury. The effects of multiple, short periods of chilling may be cumulative in some commodities. See Table 4–14, *Chilling Injury-Sensitive Vegetable Crops*, right.

Table 4–14.
Chilling Injury-Sensitive Vegetable Crops

Commodity	Min. Storage Temperature °C	Min. Storage Temperature °F	Chilling Injury Symptoms
Asparagus	2–4	36–40	darkened, water-soaked tips leading to bacterial soft rot
Basil	7–10	45–50	wilting, water-soaked appearance
Beans (snap)	7–10	45–50	russeting, pitting, corky centres
Cantaloupe	2–5	36–41	pitting and surface decay
Cucumber	7–10	45–50	surface pitting, decay
Eggplant	7–13	45–55	flesh browning, pitting, decay of cap and increased fruit rot
Okra	7–10	45–50	pitting
Pepper	7–13	45–55	water-soaked appearance, darkening, fruit rot
Potato	3–10	37–40	browning, sweetening
Pumpkins	10–15	50–59	pitting, rot
Sweet potato	13 +	55	flesh discolouration, off-flavours, hard core, increased decay
Tomato (ripe)	7–13	45–55	rubbery texture, watery flesh, seed browning
Tomato (mature green)	13 +	55+	irregular ripening, poor texture
Watermelon	10–15	50–59	surface pitting, loss of flavour, fading of red colour
Winter squash	10–15	50–59	pitting, poor flavour, increased rot
Zuchinni (summer squash)	5–10	41–50	surface pitting, rapid decay

Commodity Compatibility

Not all crops should be stored together, even if they have the same storage requirements. Some crops will give off volatile substances that interfere with the successful storage of others. For example, apples, pears, peaches, plums, apricots and tomatoes give off ethylene gas which, even in low concentrations, can cause undesirable effects in many vegetables (see the section *Ethylene*, on page 48). Potatoes may impart an earthy flavour to fruit, particularly at high temperatures. Do not store incompatible commodities in the same building unless special ventilation requirements have been made.

Storage Sanitation

Cleaning and sanitation in horticultural storage and packing areas are extremely important. Crop residue left from season to season is a prime source of the pathogens that cause post-harvest rots. Dried bacterial slime and fungal spores will survive on the walls and other surface

Table 4–15.
Proven Disinfectants

Disinfectant	Rate	Pros	Cons
Sodium hypochlorite (bleach 5.25 to 6% active)	1 part to 9 parts water	Inexpensive Readily available Quick	Corrosive Less effective when mixed with high pH water Residues may be toxic to plants if not rinsed properly
Quaternary ammonium (DCD, chemprocide)	1 mL per 300 mL water	Non-corrosive Effective at low temperatures Can be combined with detergents	Residues may be toxic to plants if not rinsed properly
Phenolic compounds (hospital disinfectants)	See label	Provide residual activity	Expensive
37% formalin solution	3L per 100 L water		Requires a respirator during application Fumes are toxic to plants. Ventilate following treatment
Potassium monopersulphate (Virkon)	0.5 to 1 % solution	Low phytotoxicity Better activity on porous surfaces (wood crates & pallets) Can be used with fogging machine Low user/envirnomental toxicity.	Corrosive under prolonged exposure (max. 30 min) Relatively expensive

areas for years. A good sanitation program involves three steps: cleaning, disinfecting and rinsing.

Cleaning

Remove debris, such as soil, wood, stones and metal, by brushing, vacuuming, scraping and high-pressure washing. High pressure wash with hot, soapy water. Water should be at least 38°C (100°F). Cleaning compounds such as soaps lower the surface tension of water so that dirt and debris may be loosened and flushed away.

Disinfecting

Disinfecting follows the cleaning step. Cleaning must be done before disinfecting. Dirt and residue will prevent the disinfectant from coming into contact with all surfaces. Many common disinfectants are deactivated by organic matter.

There are many products and procedures for sanitizing storages and equipment. See Table 4–15, *Proven Disinfectants*, above, for a short list of proven disinfectants. Exposure time is generally 10 minutes, however this may vary with the chosen disinfectant. Refer to the label for specific instructions.

Wear protective clothing (waterproof garment, safety glasses, rubber boots and gloves) during disinfecting and check the product label for specific safety instructions.

Rinsing

Rinse from the top down with clean (preferably drinking-quality) water. Leave the storage area open to air dry. If possible, force outside air into the area. This will help remove unpleasant odours that may be transferred to the produce next season.

For more information on storage, consult these OMAF Factsheets:

- *Long-Term Storage of Carrots*, Order No. 98-073
- *Storage of Cabbage*, Order No. 90-055
- *Troubleshooting Cold Storage Problems*, Order No. 94-083
- *Sizing and Laying Out a Short-Term (Summer) Refrigerated Storage for Fruits and Vegetables*, Order No. 92-124
- *Chilling Injury of Horticultural Crops*, Order No. 98-021
- *Tunnel Forced-Air Cooler for Fresh Fruits and Vegetables*, Order No. 98-031
- *Hygiene Measures in Fruit and Vegetable Storage Warehouses*. Agriculture and Agri-Food Canada, Factsheet

5. Integrated Pest Management

Integrated pest management (IPM) is an approach to pest control that uses all available control strategies to reduce pest populations of insects, mites or disease organisms below an economic injury level. It does not advocate a continuous pesticide spray program to eradicate pests. Instead, it promotes the integration of cultural, biological and chemical control strategies. By using these pest control strategies, the adverse effects of pesticides on the environment are minimized, and economic returns are maintained.

To implement an IPM program on your farm, you must have a thorough knowledge and understanding of:

- the pest (identification, biology and behaviour)
- beneficial organisms
- monitoring techniques
- use and timing of appropriate management tools
- resistance management strategies
- record keeping

In this publication, use and timing of chemical and cultural management tools and resistance management strategies are outlined. More detailed information on pest identification, biology, trapping, monitoring and record keeping techniques can be found in OMAF publications such as:

- Publication 700, *Integrated Pest Management for Onions, Carrots and Lettuce in Ontario: A handbook for growers, scouts and consultants* (Video also available)
- Publication 701, *Integrated Pest Management for Crucifers in Ontario: A handbook for growers, scouts and consultants* (Video also available)
- Publication 12, *Sweet Corn Production Manual*

Current information is also available on the crop page of OMAF's Web site at www.omaf.gov.on.ca. Additional information is supplied via newsletters, meetings, field monitoring, demonstrations and pest management workshops. For more information on available IPM programs, contact OMAF's Agricultural Contact Centre at 1-877-424-1300, or the nearest OMAF Resource Centre.

Thresholds

An IPM program uses control guidelines (thresholds) that indicate when pesticides should be applied to prevent economic losses. Timing of control measures is critical. Guidelines for insect pests are based on an economic threshold where the lost income from not applying a control will be higher than the cost of applying a control. In other words, some damage to the crop is tolerated, as long as this damage does not exceed the cost of the control. Thresholds for diseases, weeds, nematodes and vertebrates may be based on weather, site history, stage of crop development and field observations.

Monitoring

Monitoring is critical for the successful implementation of any IPM program. Monitoring allows you to forecast and evaluate potential pest problems. Effective monitoring identifies the pest present, estimates populations and recognizes conditions favourable to pest development and damage.

Monitoring allows accurate timing of pest control measures, thus reducing pesticide use. Regular monitoring will also help identify minor or secondary pest populations before they can cause significant damage.

Monitoring can include the use of traps and/or visual scouting. For a list of monitoring equipment suppliers, see Table 5–1, *Monitoring Equipment Suppliers*, on page 52.

Good record keeping is essential. Keep a site map and records of:

- status of crop health and stage of crop
- population levels of pests and beneficials
- damage observed
- location of damage
- weather and other environmental conditions
- sprays and other control measures used

Table 5–1.
Monitoring Equipment Suppliers

Company	Address	Phone	Fax	E-mail/Web site
Cooper Mill Ltd.	R. R. # 3 Madoc, ON K0K 2K0	(613) 473-4847	(613) 473-5080	e-mail: ipm@coopermill.com www.coopermill.com
Gempler's	1210 Fourier Drive, Suite 150 Madison, WI 53717	1-800-382-8473	1-800-551-1128	www.gemplers.com
Great Lakes IPM	10220 Church Rd., NE Vestaburg, MI 48891	(989) 268-5693	(989) 268-5311	e-mail: glipm@nethawk.com www.greatlakesipm.com
Natural Insect Control	R. R. # 2 Stevensville, ON L0S 1S0	(905) 382-2904	(905) 382-4418	e-mail: nic@niagara.com www.naturalinsectcontrol.com
Phero Tech Inc.	7572 Progress Way Delta, BC V4G 1E9	(604) 940-9944	(604) 940-9433	e-mail: sales@pherotech.com www.pherotech.com
Plant Products Co. Ltd.	314 Orenda Rd. E. Brampton, ON L6T 1G1	1-800-387-2449	(905) 793-9632	e-mail: sales@plantprod.com www.plantprod.com
N.M. Bartlett Inc.	4509 Bartlett Rd. Beamsville, ON L0R 1B1	(905) 563-8261	(905) 563-7882	e-mail: info@bartlett.ca www.bartlett.ca
Solida Distributors	480, rg, St-Antoine St. Ferreol-les-Neiges, QC. G0A 3R0	(418) 826-0900	(418) 826-0901	e-mail: solida@clic.net
Warwick Orchards and Nursery	R. R. # 8 Watford, ON N0M 2S0	(519) 849-6730	(519) 849-6731	e-mail: warwick@xcelco.on.ca

Trapping

Pheromone and/or sticky traps are used to collect information on the activity patterns of specific insect populations. Traps are useful for indicating the presence or absence and the relative abundance of several flying insects. However, they often catch only the adult stage of the pest and may not provide information on the damaging larval stage. Weather monitoring can improve trapping efficiency by predicting insect emergence and development.

Traps are usually placed in the field 1 to 2 weeks prior to the estimated emergence of the insect. The number of traps used and the location of the traps within the field varies with the crop and insect being monitored. Specific monitoring guidelines are available in the publications listed at the beginning of this chapter.

Keep in mind that pheromone lures are specific to the pest being trapped. They are very sensitive to contamination if they come into contact with other types of pheromones. If your trapping program involves using different types of pheromones, wear disposable latex gloves to prevent cross-contamination during handling.

Scouting

Visual inspections keep track of insects or the amount of disease actually present in the crop. Weed surveys taken across the field will aid in the selection of weed management strategies. Tools such as a hand lens or sweep nets can improve scouting efficiency.

When scouting the crop, inspect plants in several areas across the field for an accurate idea of pest pressure. Special attention is often given to monitoring border areas and fencerows. These areas are favoured overwintering sites for many insect pests. Scouting guidelines (aimed at a specific crop or pest) often indicate the number of plants that should be inspected during scouting operations. In general, a minimum of 30 plants (sometimes as many as 50 to 100) should be inspected across the field before making any pest management decisions.

Scout fields at least once a week. More frequent monitoring is recommended when the pest is most active.

For a list of available crop consultants providing monitoring services, contact OMAF's Agricultural Contact Centre at 1-877-424-1300, or the nearest OMAF Resource Centre.

Pest Control Measures

Cultural and Mechanical

Integrated pest management incorporates cultural and mechanical practices to prevent or delay the development of pest outbreaks. Management tools include:

Site Selection: Avoid locations known to be favourable for pest development.

Crop Rotation for Control of Diseases

Crop rotation can be an important practice for preventing some diseases caused by fungi, bacteria and nematodes. Rotation with a non-susceptible crop for 2–3 years usually allows enough time for plant material in the soil to completely decompose. In the absence of susceptible plant material, these organisms die off.

Rotation only works when successive crops are not susceptible hosts. It is important to remember that plants in the same family (for example, potatoes, tomatoes, peppers and eggplant) may all be susceptible to the same disease organisms. Do not rotate with plants in the same family.

Diseases that are spread by wind or by insects are generally not controlled by rotation. Many leaf blight organisms and powdery mildew fungi can blow into fields from neighbouring weeds and fields that are infested.

Crop Rotation: Many insects and diseases overwinter in crop refuse. Rotating to a non-related crop will help break the pest cycle. See *Crop Rotation for Control of Diseases*, above.

Resistant/Tolerant Cultivars: Breeding programs select varieties that are much less susceptible to disease (or sometimes insect) pressure.

Certified, Treated Seed: High-quality, vigorous seed is better able to withstand adverse weather conditions at planting. Certified seed has been produced under stringent quality guidelines and inspected to eliminate most seed-borne diseases. Treatments reduce the likelihood of losses to seed- and soil-borne diseases and insects.

Sanitation: Remove all sources of infection (including cull piles or plant refuse) from the field or greenhouse. Use sterile growing media for transplants.

Eliminate Alternate Hosts: Weeds often act as alternate hosts to many crop pests. Maintain good weed control in and around the crop. Weedy field borders often act as an entry point for weed infestations. Keep traffic-ways, borders and headlands well mown.

Inter-Cropping: Non-related crops planted in close proximity often act as a barrier to insects and diseases.

Water Management: Avoid poorly drained locations. Timely irrigation will supply the crop's needs without exposing it to unnecessary levels of soil and leaf wetness.

Optimize Plant Health: Ensure rapid germination by planting into appropriate environmental conditions. Manage nutrients to ensure a vigorous plant, without contributing to excess top growth. Windbreaks can protect the crop from sandblasting and early-season damage. Avoid compacted locations.

Chemical Controls

Chemical controls include synthetic, inorganic and biological pesticides. They kill target pests and limit subsequent populations. They are important tools for crop protection when used as part of an IPM program.

Understand the pest's life cycle and apply chemicals at the stage when the pest is most vulnerable. To control insects, monitor fields closely. Spray according to action thresholds or at critical stages of crop development. To control disease, apply protective fungicides when weather conditions are favourable and before infection occurs.

Beneficials

Beneficials are natural enemies of the crop pest. These predators (including parasites and pathogens) help suppress pest populations.

These agents will not eliminate damage by pests. However, once they are established, they can maintain pest populations at lower levels. They are also effective at controlling indirect pests such as aphids, leafhoppers and mites. They are less effective at keeping populations of direct pests (those attacking the harvested product) at levels acceptable for commercial production. One of the advantages of beneficial insects is that their activities can prevent or delay the development of pesticide resistance.

Resistance Management

Resistance occurs when a pest is able to survive exposure to rates of pesticides that previously controlled it. Generally, resistance to a pesticide develops after repeated exposure to a specific chemical. Resistance occurs because a few naturally occurring resistant individuals survive after each spray, while the susceptible portion of the population is killed. These resistant survivors multiply and gradually replace the susceptible ones. Eventually

the resistant population dominates, and the pesticide loses efficacy.

Resistance to pesticides can develop very quickly. Do not use the same chemical repeatedly unless it is used in rotation with a different chemical or used in combination with other chemicals having a different mode of action.

Many chemicals with the same active ingredients are marketed under different brand names. For example, the insecticide chlorpyrifos is marketed under the brand names Lorsban, Pyrifos and Pyrinex. Different chemicals may also have the same mode of action. For example, both Assail and Admire have the same mode of action. Using Assail after Admire is equivalent to using Assail after Assail, since resistance to both chemicals develops at the same time, even though only one may have been used repeatedly. The same applies for the pyrethroid family.

The pest control recommendation tables in Chapter 6, *Crop Management Recommendations,* starting on page 61, list the chemical group for each control product. Over the course of the season, rotate between products from different chemical groups.

General Insects and Diseases of Vegetable Crops

There are a number of pests that attack a wide range of crops. Descriptions of the pests and cultural control methods are listed here.

For chemical control methods, refer to the individual commodity sections in Chapter 6, *Crop Management Recommendations,* starting on page 61.

Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)

Crops Affected: Most vegetable crops.

Symptoms: Seedlings affected by damping-off generally rot at ground level and topple over. Other symptoms may include seed decay, rotting roots and cankers on lower petioles.

Incidence: Plants are usually infected by damping-off during the seedling stage. Cool, wet springs when plants are slow to emerge and develop are particularly problematic. Root rots generally occur during periods of warm, wet weather and may affect the plant at any stage of development.

Thresholds: None established.

Management Notes: Sterilize flats and soil for growing seedlings (see the section *Vegetable Transplants,* on page 175). Use fungicide-treated seed and plant only when soil and weather conditions are favourable for vigourous crop development. See also Table 4–3, *Minimum Soil Temperature Conditions for Vegetable Seed Germination,* on page 38. Refer to the commodity sections of Chapter 6, starting on page 61, for seed treatment recommendations.

Aphids

Crops Affected: Most vegetable crops.

Symptoms/Identification: Aphids are small, pear-shaped insects, with cornicles or "tail-pipes" near the tip of their abdomen. They are typically found in colonies. Aphids pierce the leaves and suck the sap from many vegetable crops. Their feeding causes leaf distortion.

Aphids produce a sticky substance called "honeydew," which can promote the development of secondary moulds (sooty mould.) These moulds may affect marketability.

Aphids also act as the primary vectors of several economically significant virus diseases. Non-colonizing aphids move through the crop in search of suitable host plants, spreading the virus. With many viruses, the disease infection occurs after less than one minute of feeding. The management of aphid populations with insecticides does little to prevent the spread of viruses.

Period of Activity: Aphids are present throughout most of the growing season. However, populations build quickly during hot, dry weather. Aphid populations are often kept below threshold levels where predators (ladybird beetles, lacewings, minute pirate bugs, other) are present in abundance.

Thresholds:

Peppers	No threshold is established, but more than 10 per leaf could be potentially damaging.
Sweet corn	10% of ears infested (ears with more than 20 aphids are considered infested.)
Tomatoes	5 aphids per 10 leaflets per plant
Potatoes[1]	4 aphids per leaf (check 1 lower leaf on 50 plants)

[1] Keep seed potato fields free of aphids at all times.

Management Notes: The continuous use of broad-spectrum insecticides may disrupt beneficial populations, resulting in aphid resurgence. Note that the sunflower aphid and the green peach aphid may have developed resistance to insecticides in some areas.

For more information, refer to the OMAF factsheet, *Aphids infesting Lettuce and Celery in Ontario*, Order No. 00-053.

Cutworms

Crops Affected: Many vegetable crops.

Symptoms/Identification: There are several species of cutworm. The larvae are soft and fat, and they roll up when disturbed. Look for cutworm larvae in the top 2.5 cm (1 in.) of soil surrounding the damaged plant. Early season cutworms attack the seedling plants, usually cutting them below or at the soil surface. A single larva may destroy several seedlings.

Period of Activity: Most species of cutworms feed at night, hiding during the day under loose stones or in the soil near the base of the plant. Plants at the seedling stage are most vulnerable to cutworm losses.

The variegated cutworm appears later in the season. It is larger than the other species and feeds on the foliage of tomatoes, potatoes, peppers and eggplant, as well as damaging and contaminating tomato fruit.

Black cutworms may cause serious damage in potatoes by feeding on the tubers late in the season.

Thresholds: For most vegetable crops, the control guideline is 5% damaged plants. Other thresholds are as follows:

Crop	Threshold
Potatoes	Sporadic pest. Monitor populations with pheromone traps.
Sweet corn	10% damage, if plants are less than 4–6 leaves and larvae are less than 4 cm (1.5 in.)
Tomatoes (scouting)	1 larva per 30 plants
Tomatoes (pheromone traps)	7 moths per trap per week (Use in combination with field scouting.)

Management Notes: Migrating female moths are attracted to weedy fields in the early spring for egg-laying. Damage is often sporadic.

Early-season cutworm control is most effective on small (less than 2.5 cm or 1 in.) larvae. Larger larvae are difficult to control with insecticides. At more mature stages (>2.5 cm or 1 in. in length), they cease feeding as they prepare to pupate, and control becomes unnecessary.

Apply insecticides in the early evening, as the cutworms come to the surface to feed. Insecticides are more effective on moist soils. Climbing (variegated) cutworm control should be applied before the larvae reach 2.5 cm (1 in.).

See the individual commodity sections in Chapter 6, starting on page 61, for cutworm chemical control recommendations.

For more information, refer to the OMAF Factsheet *Managing Cutworms in Vegetable Crops*, Order No. 00-055.

Seedcorn Maggot

Crops Affected: Beans, cucurbits, nappa cabbage, onions, potatoes and sweet corn.

Symptoms/Identification: These small white maggots feed on the swollen, ungerminated seed of vegetable crops. Poor stand establishment is often a symptom of infestation.

Seedcorn maggot flies will lay eggs inside the heads of Nappa cabbage during hot, dry conditions. Larvae then feed on the inside head leaves, creating a ragged appearance, rendering the heads unmarketable.

Period of Activity: Maggots are usually a problem in direct-seeded crops during cool, wet springs when germination is delayed. Adult flies lay their eggs from April until the middle of June.

Thresholds: None established.

Management Notes: Use one of the insecticide-seed treatments recommended in the commodity sections of Chapter 6. Egg-laying females are attracted to moist soils and the odour of decaying organic matter. Discourage egg-laying by applying and incorporating manure well in advance of planting.

Slugs

Crops Affected: Beans, celery, cole crops, eggplant, lettuce (chicory, endive), peppers, potatoes, rhubarb, sweet corn and tomatoes.

Symptoms/Identification: These soft-bodied, legless, grey mollusks feed above or below ground, depending on the soil moisture level. Slugs have rasping mouthparts and will create ragged holes on the lower leaves, sometimes leaving a "window-pane" of waxy cuticle behind.

Severely affected plants may become skeletonized. Under high populations, slugs also attack seeds and emerging seedlings. A slime trail is usually observed at the feeding location.

Period of Activity: Slug damage is most severe in years when there is prolonged cool, wet weather during May and June.

Thresholds: None established.

Management Notes: Most plants can successfully outgrow light feeding damage. Cultivating fields where slug pressure is high can help reduce the slug population. Tillage exposes the slugs to dehydration and predation by birds and mammals.

Removing weeds and crop residue from the zone immediately surrounding young seedlings may also help reduce damage. Zone tillage can remove slug habitat, while maintaining the benefits of reduced tillage.

Refer to the commodity sections of Chapter 6, starting on page 61, for chemical control recommendations.

Tarnished Plant Bug

Crops Affected: Beans, celery, cole crops (including Asian crucifers), cucurbits, eggplants, lettuce, peppers, potatoes and tomatoes.

Symptoms/Identification: Tarnished plant bugs (TPB) cause a broad range of damage on vegetable crops. Symptoms include:

- stings and lesions on celery stalks
- reduced fruit set on beans, peppers and eggplants
- stings and blemishes on tomato fruit
- necrotic spots on the florets and curd of broccoli, cauliflower
- dead leaves on potatoes and vine crops

Period of Activity: The tarnished plant bug is a sporadic pest, present in Ontario throughout the growing season. Tarnished plant bug adults are highly moblie, moving readily from adjacent crops when disturbed by harvest activities.

Thresholds:

Celery and lettuce	0.1 to 0.2 TPB per plant
Tomatoes	1 nymph or adult per 30 plants (after fruit set)

Management Notes: Tarnished plant bugs breed on many common weed species, including chickweed, dandelion, lamb's-quarters, ragweed and fleabane. Weed control in and around vegetable plantings will help reduce potential infestations.

> For more information, consult the OMAF Factsheet, *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025.

Wireworm

Crops Affected: Carrots, onions, sweet corn, potatoes, vine crops, eggplant, potatoes, tomatoes, peppers and sugarbeets.

Symptoms/Identification: Wireworms are copper-coloured, cylindrical and hard-bodied. They have 3 pairs of tiny legs near the head-end and are commonly confused with the multi-legged millipede (a beneficial soil insect) and symphalans.

Wireworms can be seen burrowing into the ungerminated seeds, as well as underground roots and stems of plants. Infested plants do not develop well, and seedlings lack vigour or fail to emerge. Damage is often scattered randomly across the field.

Period of Activity: Wireworms are present all season. Young plants are most susceptible, therefore early-season control is critical. Wireworms have a life cycle of several years. They are likely to be present in fields with a history of the problem or in fields that have recently had sod crops.

Thresholds: Wireworms may be monitored in the fall (or in the early spring for later-planted crops) using bait stations. Bury whole carrots, 7.5 cm (3 in.) deep, at 10 marked stations across the field. Check the stations in 2–3 days. A count of 0.5 to 1 wireworm per station indicates a potential problem. Make your planting and seed treatment decisions accordingly.

Table 5–2.
Nematodes Impacting Vegetable Crops in Ontario

Nematode Species	Crops Affected	Symptoms	Thresholds
Root lesion	most vegetables	brownish, scratch-like wounds on plant roots	tomatoes: 2,000/kg soil[1] other vegetables: 1,000/kg soil 50/g dry root
Root-knot	most vegetables	galls develop on plant roots poor growth, patchy distribution in field	carrot: zero tolerance root vegetables[2]: 500/kg soil (spring sample) other vegetables: 1,000/kg soil
Sugarbeet cyst	beets, spinach, cole crops and other root crops	stunted plants outer leaves wilt, turn yellow prematurely and die white or brown cysts can be seen on washed roots	2000 larvae or eggs/kg of soil, or >250 cysts/kg soil, or 200 eggs/100 g of soil
Bulb and stem	onions, garlic, leeks, shallots	twisted and deformed plants, with shorter, thicker leaves (known as "onion bloat") splitting and cracking of infected bulbs	100/kg soil

[1] Tomato threshold is for newer, processing varieties with vigorous growth. For older, or fresh-market varieties, use 1,000/kg soil as the threshold.
[2] Root vegetables include parsnips, potatoes, onions and other tuberous crops.

Management Notes: Refer to the individual commodity sections of Chapter 6, starting on page 61, for a list of registered insecticide-seed treatments and in-furrow options. Planting into well-prepared, warm soils and avoiding unnecessarily deep planting depths will help to encourage early season growth, reducing the incidence of this pest.

White Grubs

Crops Affected: Table beets, carrots, cole crops, potatoes, and sweet corn.

Symptoms/Identification: White grubs are the larvae of the June beetle, European chafers and (in some areas) Japanese beetles. The larvae are C-shaped with a white body and darker head. Severe feeding damage early in the season may cause the plant to dwarf, become wilted and die. Feeding on root crops (potatoes, beets, carrots) renders them unmarketable.

Period of Activity: European chafer (an annual grub) overwinter as early instar larvae. Peak feeding occurs in April to mid-May. Larvae pupate in the late spring, after which time they are not usually a problem in vegetable crops.

June beetle larvae are present in the soil for 3 years. Feeding is most noticeable in the late spring. However, damage may occur throughout the growing season on root crops.

Thresholds: None established. Look for grubs in the crop row, approximately 5 cm (2 in.) below the soil surface. Older pupae of the June beetle larvae may feed on deeper roots, up to 25 cm (7 in.)

Management Notes: To avoid injury by white grubs, wait 2 or more years before planting vegetables on land that had been planted with grass sod. Where white grubs have been identified prior to planting (or in replant situations) consider planting to a non-host crop, such as beans. Where European chafer is the problem, delaying planting to late spring may eliminate the problem.

Nematodes

Root-lesion, root-knot and sugarbeet cyst nematodes are responsible for most nematode problems in Ontario vegetable crops. A crop may be attacked by the combined action of two or more kinds of nematodes. In some cases, nematodes aggravate fungal diseases. For example, root-lesion nematodes worsen verticillium wilt of eggplants, tomatoes and potatoes.

Before deciding upon a management strategy for nematodes, a nematode soil test must be completed to determine the levels of nematodes present. In Ontario, nematode populations are usually at their highest in May-June and again in September-October. See Appendix H, *Diagnostic Services*, on page 195, for sampling and testing information.

Table 5–2, *Nematodes Impacting Vegetable Crops in Ontario*, above, outlines the various treatment thresholds associated with specific nematode species.

Table 5–3.
Nematode Fumigant Control Recommendations [1]

Trade Name	Active Ingredients	Rate[2]		Notes
Basamid Granular	dazomet	**eggplant, lettuce, pepper & tomato** ***seed beds:*** 3.25–5 kg/100 m^2		Apply to cultivated, moist soil only. Incorporate immediately after application. Seal immediately after incorporation. May not control cyst-nematodes. Refer to label for appropriate planting intervals.
Busan 1020	metam sodium	***seed beds:*** .75–1 L per 10 m^2 ***field application:*** 375–935 L/ha		Inject into well-cultivated, moist soil only. Refer to the label for sprinkler recommendations. Planting may take place 21 days after treatment if soil is well drained, light-textured and relatively dry and warm.
Telone II	1,3 dichloropropene	**Mineral**	**Muck**	Apply to cultivated, moist soil only. Seal soil surface immediately after application. Leave soil undisturbed for 7–14 days after application. A longer waiting period may be required if the soil is cold and/or wet.
		cole crops & cucurbits		
		broadcast: 112 L/ha ***rows:*** 65 L/ha	200 L/ha 100 L/ha	
		other vegetables		
		broadcast: 135 L/ha ***rows:*** 65 L/ha	200 L/ha 100 L/ha	
Telone C-17	1,3 dichloropropene and chloropicrin	***broadcast:*** 160 L/ha ***100-cm rows:*** 65 L/ha	380 L/ha 120 L/ha	Same as above
		greenhouse beds: 2 L/100 m^2		
Vapam 7	metam (sodium, anhydrous)	***seed beds:*** 1L /10 m^2 (apply in 80 L of water) ***soil injection:*** 550–900 L/Ha		Apply to cultivated, moist soil only. Seal soil immediately after application. Planting may take place 21 days after treatment if soil is well drained, light-textured and relatively dry and warm.

[1] **All toxic gases must be aerated from the soil before planting.** Fumigation may temporarily raise the level of ammonia, nitrogen and soluble salts in the soil.
[2] **Always** refer to the label for complete instructions before applying a fumigant.

Nematode Control

Caution

Carefully follow the manufacturer's directions for the use of soil fumigants. You must have a permit to apply methyl bromide. A permit may be obtained from the Pesticides Control Section, Ministry of the Environment, 135 St. Clair Ave. W., Toronto, M4V 1P5, Tel (416) 323-5095.

Always follow the instructions on the label carefully regarding rates and application method. Shank-injection of fumigants is preferable to reduce the chance of wind-and-odour drift, runoff or other mishaps. Muck soils often require higher rates.

Soil can be fumigated either in the fall or in the spring. At the time of fumigation, the soil temperature should be at least 4°C (39°F) at the 15-cm (6 in.) depth. Prior to application, work the soil to a depth of 20–25 cm (8–10 in.). The moisture content of the soil must be at a level that would permit good seed germination.

With fall applications, the soil should be worked several weeks before fumigation so that the area is reasonably free from undecomposed crop residue. The soil should not be disturbed after sealing until the normal spring cultural operations are started.

After spring fumigation, cultivate the soil thoroughly before planting to aerate and ensure that all traces of fumigant odour have dissipated.

Do not use nematicides containing bromine before planting onion, beet, celery or potato.

See Table 5–3, *Nematode Fumigant Control Recommendations*, above.

For more information, see the OMAF Factsheet, *Land Preparation — A Key to Successful Soil Fumigation*, Order No. 89-177.

Birds

Bird control methods must be in place *at least* 10 days before the crop becomes attractive for feeding. This is not necessarily 10 days before the crop is ready for harvest. Once the birds have found a food source, it is very difficult to scare them away.

Birds quickly become accustomed to uniform movements and noise patterns. Moving scare devices to new locations on a regular basis will greatly improve control. The randomness of a noise device is of paramount importance. The frequency and level of the noise are secondary.

Visual Deterrents

There are several visual bird deterrents available to growers. Scare-eye balloons, flashing tape, mirrors and predator shaped kites are generally not as effective as the noise-making repellants. However, when used in combination, they can improve the efficiency of the acoustic scare devices.

Acoustic Devices

There are three principle types of acoustic scare devices. They include propane-fired cannons, electronic sound devices and digital distress calls.

Propane-Fired Cannons

Bird-bangers are the industry standard. These units are most effective when the timing of the blast is randomized. The cannon should never blast at intervals of less than 3 minutes. Frequent intervals will only cause the birds to become accustomed to the noise. The efficiency of the bird-banger will also be increased if the unit is moved regularly.

In built-up areas, the propane-fired cannon may greatly disturb the neighbours. In such a setting, the less invasive AV Alarm and Bird Gard devices may be more appropriate.

Electronic Sound Devices

The AV Alarm makes an electronic warbling sound. This noise is irritating to birds and interferes with their sensory system. In short, it makes them edgy and easily scared. These units work particularly well in combination with propane cannons. Visual repellants may also work well in combination with the AV Alarm.

Digital Distress Calls

These electronic devices play digitally encoded bird distress calls over a speaker system. Birds mistake the calls for a warning of danger and abandon the field. The distress call has been known to attract predator birds such as hawks. The presence of hawks flying in the area will also act to deter feeding birds.

Bird Gard units are programmable, with a selection of different bird calls to chose from. This allows the units to be customized to focus on the species of bird causing the problem. The distress calls are played in a random sequence, with predator calls interspersed.

Units can operate on a timer or a light sensor, deactivating them when birds are not feeding. The device runs off a 12-volt car battery. It will generally last 10 days between charging.

These units are of particular use in more built-up settings. As it sounds like the call of real birds, nearby neighbours are less likely to be disturbed by it.

For more information, see the OMAF Factsheet, *Bird Control on Grape and Tender Fruit Farms*, Order No. 98-035.

Deer, Groundhogs, Raccoons and Rabbits

Deer, groundhogs and rabbits can be a serious problem in vegetable plantings, particularly in areas where woodlots or brush surround vegetable fields. Deer and groundhogs will often root for carrots in harvested fields. Raccoons are a serious pest of sweet corn. Trapping groundhogs and raccoons may help reduce the problem.

Hinder is registered as both a deer and rabbit repellent. It can be applied using normal field spraying equipment. The rate to use depends on the severity of the problem. Hinder, at 2–4 L/100 L should be applied at a volume of 450–950 L of water/ha (180–380 L/ac). This results in

an actual application range of 9–39 L of Hinder product/ha (3.6–15.6 L/ac).

Hinder acts as a scent repellent. It is important that the edges of the affected fields, particularly areas where the deer or rabbits enter, be thoroughly covered with spray solution. For more information on deer control, see OMAF Publication 10, *Deer Control Practices in Agriculture.*

6. Crop Management Recommendations

ASPARAGUS

Production Requirements

Asparagus is a long-term vegetable crop that should produce viable yields for 15 or more years. Thorough planning is essential for success. Field selection and preparation are important for long-term production.

Average Yields

Crop	per acre	per hectare
Provincial average	2,100 lb	2,300 kg
All-male hybrid (established)	3,000–4,000 lb	3,300–4,500 kg

Cultivars

Consult plant and seed suppliers for descriptions of varieties and availability of plants 1 year in advance of planting. A list of asparagus crown producers is available on the OMAF Web site at: www.omaf.gov.on.ca.

Field Selection and Preparation

Plant into well-drained sandy or sandy-loam soils free of perennial weeds and grasses. Soil testing is highly recommended to determine fertility levels and pH before transplanting. Soil pH should range between 6.0 and 6.8. If possible, use a green-manure crop or livestock manure before planting, to increase soil organic matter.

Avoid planting asparagus into fields that have previously grown asparagus. Asparagus yields decline over time due to two important *Fusarium* diseases commonly found in asparagus soils. See the section *Crown Rots (Fusarium sp.)*, on page 62, for more information.

Growing Seedlings

Soak seed in 32°C (90°F) water for 3–4 days. Dry and sow immediately into fertile, well-prepared soil. Seed in mid-May or once the ground is prepared and warm enough for seeding. Optimum soil temperatures for germination are 15°C–30°C (59°F–86°F.)

To allow for selection of strong plants, plan to grow more crowns than are needed. One kilogram of good seed should provide enough crowns to plant 1 ha (0.89 lb/ac).

Nursery

Row spacing:	45–60 cm (18–24 in.)
In-row spacing:	8–10 cm (3–4 in.)
Depth:	2.5–4 cm (1–1.5 in.)
Rate:	approximately 11 kg of seed/ha (10 lb/ac)

Transplanting and Spacing

Dig the 1-year-old nursery plants in early spring. Discard the weak or small crowns (less than 20 g or ¾ oz). Up to one-third of the total crowns may be discarded. Plant crowns as soon as possible after digging.

Row spacing:	1.2–1.5 m (4–5 ft)
In-row spacing:	22–30 cm (9–12 in.)
Depth:	top of crown should be 15 cm (6 in.) deep

Fertility

Green manure crops planted in the year prior to asparagus establishment require 30–40 kg N/ha (27–36 lb N/ac) prior to or at seeding. Apply P and K based on crop requirements and soil tests.

Nitrogen

See Table 6–1, *Asparagus Nitrogen Recommendations*, below.

Table 6–1.
Asparagus Nitrogen Recommendations

Method	Actual N kg/ha	Actual N lb/ac
Nursery	75[1]	67[1]
New plantings	110[2]	98[2]
Established plantings:		
Pre-harvest	55	49
Post-harvest	55	49
Total	**110**	**98**

[1] An additional 50 kg nitrogen/ha may be applied as a side-dress application in August or early September if rainfall was excessive in the summer.
[2] Broadcast all the recommended nitrogen and potash prior to planting.

Table 6–2.
Asparagus Rust Control Recommendations[1]

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	Notes
zineb	dithiocarbamate	Zineb 80 W	2.5–2.75 kg	1–1.1 kg	
metiram	dithiocarbamate	Polyram DF	2.25–3.25 kg	1–1.3 kg	Use high rate on full-grown fern.
myclobutanil	triazole	Nova 40 W	340 g in 370 L water	136 g in 150 L water	Maximum 5 applications/yr.
propoconazole	triazole	Topas 250 E	250 mL	100 mL	Apply at 14–21-day intervals. Maximum 3 applications/yr.

[1] Apply rust control products *after* the harvest season.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.) Take the soil sample at the depth of planting.

Band the phosphate below the crowns at planting.

Integrated Pest Management

Diseases

RUST

Identification: Look for dark, oval-shaped, raised pustules on the stems and fronds after harvest. Rust-coloured spores are often easily seen in the centre of the lesions.

Development: The rust fungi overwinter in the field, on crop debris. Infection of growing foliage can occur from April through to early September. Warm weather with heavy dew or light rainfall promotes rust development.

Thresholds: None established.

Management Notes: Some asparagus varieties do have moderate levels of rust resistance. The fungicides listed in Table 6–2, *Asparagus Rust Control Recommendations*, above, are best used in a preventative program. Protect plantings as soon as the fronds are about 30 cm high (late May for new plantings, early July for established ones). Maintain a 7- to 10-day schedule until late August to protect the fern growth. Thorough coverage of the entire canopy is important.

PURPLE SPOT (STEMPHYLIUM)

Identification: Tan-to-brown, sunken, elliptical lesions with purple edges appear on infected spears, stems and fronds. Harvest infections reduce the marketability of the crop. Severe summer infections result in the premature defoliation of the fern, reducing the following year's yields by up to 52%.

Development: Stemphylium overwinters on asparagus crop residue. Harvest infections often occur after sand-blasting or high wind have damaged the spears. These microscopic wounds are an important point of entry for the fungi. Once established, stemphylium will continue to release spores for the duration of the growing season, infecting new fern as it emerges.

Management Notes: Where infection has been severe, consider destroying infected fern and plant debris, which are sources of overwintering spores. Reduced tillage and the use of cover crops and wind breaks can help reduce the occurrence of sand blasting.

CROWN ROTS (*FUSARIUM* SP.)

Identification: Crown rots caused by *Fusarium oxysporum* and *Fusarium moniliforme* cause yield decline and can limit the productive life of an asparagus planting.

Development: Both types of *Fusarium* are soil-borne fungi. *F. oxysporum* is found in all soils. Concentrations increase in soils over time as plants become infected. *F. moniliforme* is hosted by both asparagus and corn.

Management Notes: Avoid planting into fields that have previously grown asparagus. It will take at least 5 years after an asparagus crop for soil levels of *F. oxysporum* to decrease to "normal" levels. Avoid planting where corn has been grown in the previous 3 years.

Minimize tillage and use zero-tillage practices where possible. Excessive and deep cultivations can injure crowns and increase *Fusarium* infection.

Vigorously growing asparagus plants are less susceptible to crown rots. Care should be taken to avoid stressful growing conditions caused by overpicking, pest pressure, weed competition, soil compaction and low fertility.

Table 6–3.
Asparagus Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aphids						
pirimicarb	carbamate	Pirimor 50 DF	1 kg in 675 L of water	0.4 kg in 270 L of water		Post-harvest only.
dimethoate	organophosphate	Lagon 480	2.3 L in 675 L of water	0.9 kg in 270 L of water		
		Cygon 480	2.3 L in 675 L of water	0.9 kg in 270 L of water		
Asparagus Beetle						
deltamethrin	pyrethroid	Decis 5 EC	200 mL	80 mL		Post-harvest only.
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL	56 mL	1	
carbaryl[2, 3]	carbamate	Sevin XLR plus	2.5–6.4 L	1–2.56 L	2	Do not treat more than once every 3 days.
methoxychlor	diphenylethane	Methoxychlor 240	4–10 kg	1.6–4 kg	3	Use higher rate on dense fern.
malathion	organophosphate	Malathion 500 E	2.5 L	1 L	1	
		Malathion 25 W	5.5 kg	2.2 kg	1	
rotenone	botanical	Rotenone 5% WP	6 kg	2.4 kg	1	Use a non-herbicidal spreader.
Cutworms						
carbaryl	carbamate	Sevin XLR Plus	2.5–6.4 L	1–2.56 L	2	Late-season (climbing) cutworms only. Do not treat more than once every 3 days.
permethrin	pyrethroid	Pounce 384 EC	180–295 mL	72–118 mL	2	Use high rate on dry soils.

[1] DHI = Days to Harvest Interval
[2] Use only during harvest, not during fern growth period.
[3] See the section *Bee Warning*, below.

For more information, see the OMAF Factsheet, *Diseases of Asparagus*, Order No. 82-045.

Insects

APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting asparagus, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–3, *Asparagus Insect Control Recommendations*, above.

ASPARAGUS BEETLE

Identification: These blue-black beetles with red wing margins and their larvae can reduce asparagus vigour by feeding on the fern during establishment and after harvest. Feeding injury and eggs laid on the spears during harvest can impact the marketable yields.

Period of Activity: Beetles overwinter as adults in crop residue and sheltered areas (such as pine wind breaks.) Beetle emergence usually coincides with asparagus harvest. First generation larvae are often active after harvest, during fern establishment. A second generation of adults (and larvae) emerge in late July.

Thresholds:

Eggs:	2 eggs on 10 spears
Larvae	50% of plants with larvae present, **or** 10% defoliation
Adults:	5%–10% of plants infested

Management Notes: Time field monitoring for the afternoon when asparagus beetles are more active.

Bee Warning

Dimethoate is toxic to bees and should not be used during the bloom period. Carbaryl is especially toxic to bees and should not be used during the fern-growth period. With other insecticides, losses of bees can be reduced if sprays are applied in early morning or late evening when the bees are not foraging. Advise local beekeepers of spraying activity (see the section *Prevent Bee Poisoning*, on page 8).

Mechanical Injury

Hooking

Bent spears are caused by injury to the spear, either above or below ground. Where sandblasting is a problem, spears will "hook" into prevailing winds. Below-ground injuries causing hooking include cutworm feeding, inadvertent nicks from cutting knives and abrasions from sharp stones, cultivators, etc.

Fall-seeded cover crops help maintain soil organic matter while preventing both water and wind erosion the following spring. Broadcast 4 bu/ha of rye in late August to mid-September. Use a burn-down herbicide in the spring.

Physiological Disorders

Hollow Stem

This problem tends to be more prevalent in young spears during periods of warm, wet weather resulting in very rapid spear growth. Seasons with moderate temperatures and even growth will result in a low incidence of hollow stems. Although this problem does not affect the eating quality of the spear, it may reduce marketability.

Harvest

Healthy asparagus plantings can be harvested for about 10–14 days at the beginning of the third season after field setting. For example, if the field is set in the spring of 2004, the first limited harvest would be in the spring of 2006. The harvest season increases by 1–2 weeks per year, up to a maximum of 6–8 weeks.

The length of the harvest season is determined by plant vigour and spear size. Stop harvesting when 75% of the spears are smaller than 1 cm ($^3/_8$ in.) in diameter. If weeds, insects, disease or adverse weather conditions reduced plant vigour in the previous season, decrease the harvest duration accordingly.

Storage

Freshly harvested asparagus is very perishable and rapidly loses quality. Collect the spears from the field as soon as possible, protect them from the sun and move them to cold storage. Store under high humidity at 1°C–2°C (34°F–37°F).

Hydrocooling is an effective and rapid way of removing field heat from asparagus spears. Under good conditions, asparagus will store for 2–3 weeks.

Fern Disposal

Clip asparagus fern in the fall, leaving 15–20 cm (6–8 in.) of stubble to catch drifting snow for better crown protection. The stubble can be cut up with a rotary or flail-type mower in early spring. The fern contributes organic matter to the soil and helps prevent early-season wind erosion.

BEANS

Production Requirements

Snap beans are grown on all types of soils, with the exception of very heavy clay loams. They require well-drained locations with good fertility. The maturity of snap bean varieties grown in Ontario ranges from 48–78 days from planting to harvest. Harvest usually occurs 7–10 days after full bloom.

Average Yields

Crop	per acre	per hectare
Processing (green and yellow)	3 tons	6.7 tonnes
Processing (lima)	1 ton	2.2 tonnes
Fresh market (green and yellow)	200 crates	500 crates

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Spacing and Seeding

Sow as shallow as soil moisture permits, usually 2.5–4 cm (1–1.5 in.) deep. Lima bean seed may be planted up to 5 cm (2 in.) deep, depending on soil moisture. Snap beans require a minimum soil temperature of 13°C (55°F) at the time of planting. Lima beans require slightly warmer planting conditions: 15°C (59°F).

Planting into cool soil conditions may result in reduced stands due to poor germination, low vigour and increased seed decay. Under good soil conditions, germination should occur within 6–10 days of planting.

The row spacings and seeding rates in Table 6–4, *Snap and Lima Bean Spacing and Seeding Rates*, right, are suggested for optimum yields depending on the harvest method. Because seed size varies greatly between cultivars, adjust the seeding rate according to seed count and the germination percentage. Increase the seeding rate slightly if seeding in cool soils to compensate for reduced stands. ***Note:*** Dark-coloured seeds have better cold soil emergence.

Table 6–4.
Snap and Lima Bean Spacing and Seeding Rates

Crop	Row Spacing cm (in.)	In-Row Spacing cm (in)
Snap beans (hand harvest)	75–90 (30–36)	5–10 (2–4)
Snap beans (machine harvest)	60–75 (24–30)	5–10 (2–4)
Lima beans	60–75 (24–30)	10–20 (4–8)

Fertility

Nitrogen

Apply 30–40 kg N/ha (27–36 lb N/ac) prior to planting. This may be applied as a preplant broadcast application or banded through the planter, 5 cm below and 5 cm to the side of the seed. Side-dressing of nitrogen is only recommended following heavy rains if foliage shows nitrogen deficiency. Over-application of nitrogen will cause excess leaf growth, resulting in uneven maturity.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

Fertilizer may be broadcast and incorporated before seeding or banded 5 cm below and 5 cm to the side of the seed. Because high rates of banded potassium can damage emerging seedlings, banded potassium should not exceed 60 kg potash/ha.

Micronutrients

BORON

Beans are very sensitive to boron toxicity and should not be grown the year after boron has been applied to previous crops in the field, such as cole crops, celery or rutabaga.

MANGANESE

Manganese deficiency may be a problem on beans, especially on soils with pH values above 6.5. Correct the deficiency as soon as detected with a foliar manganese spray. Soil application is not recommended for manganese because of the large amounts required. See the section *Manganese*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

For more information on the identification and management of these diseases, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. Also see Table 6–5, *Bean Seed Treatments*, on page 66.

Table 6–5.
Bean Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Insecticide and Fungicide Combinations				
Agrox B-2	diazinon + captan	80g per 25 kg seed	Seed corn maggots, seed decay, damping off	Use within one month of treatment.
Agrox CD	diazinon + captan	50 g per 25 kg seed	Seed corn maggots, seedling blight, seed rot.	Use only on seed previously treated with a fungicide.
Fungicide Only				
Apron XL LS	metalaxyl-m	20–40 mL per 100 kg seed	Damping-off and root rot (high rate controls phytophthora root rot)	For use in commercial seed treatment plants only.
Apron FL	metalaxyl	46–110 mL per 100 kg seed	Pythium seed rot and seedling blight.	Do not feed to livestock for 4 weeks after planting.
Allegiance FL	metalaxyl	46–110 mL per 100 kg seed	Pythium seed rot and seedling blight.	Do not feed to livestock for 4 weeks after planting.
Vitaflo	carathiin + thiram	260 mL per 100 kg seed	Pythium seed rot and seedling blight.	For use in commercial seed treatment facilities Do not feed to livestock for 4 weeks after planting.
Captan FL	Captan	70 mL per 25 kg seed	Seed decay, damping-off and root rot	
Thiram 75 WP	Thiram	25–35 g per 25 kg seed	Seed decay and damping-off	Do not feed treated clippings to livestock

WHITE MOULD (SCLEROTINIA)

Identification: Symptoms develop on the pods, branches or stems during or after flowering. Dark-green water-soaked lesions enlarge rapidly, encompassing the branches and stems, causing leaves to turn yellow and die. White, cottony fungal growth may develop on pods and stems.

Development: Bean plants are most susceptible during flowering and early pod development. Temperatures ranging from 20°C–25°C (68°F–77°F) and continuous leaf wetness (high humidity and/or heavy dews) favour sclerotinia white mould development. Overwintering sclerotia may survive for several years in the soil.

Thresholds: None established.

Management Notes: Practice a 3–4-year crop rotation away from susceptible crops (vine crops, edible beans, soybeans, carrots and lettuce). Reduced tillage may decrease the number of sclerotia present to germinate at the soil surface. Excess nitrogen applications may result in an exceptionally dense canopy, resulting in restricted air movement and more favourable disease development conditions.

See Table 6–6, *Bean Disease Control Recommendations*, on page 67. If humid or wet weather persists during bloom, a second spray may be necessary.

BACTERIAL BLIGHTS (BROWN SPOT, COMMON BLIGHT, HALO BLIGHT)

Symptoms: The three bacterial blights are difficult to distinguish in the field. On leaf tissue, look for circular, brown, necrotic lesions, often surrounded by a yellow border. Pod lesions are usually slightly sunken and dark reddish-brown. The pods often become misshapen where the lesions develop.

Development: Common blight usually occurs during warm, humid conditions of 25°C–30°C (77°F–86°F). Halo blight prefers cooler temperatures in the 16°C–20°C (61°F–68°F) range.

Thresholds: None established.

Management Notes: Use only certified seed. The bacterial blight pathogens do not generally overwinter on crop residue in Ontario. Plants damaged by high winds or sand blasting are more susceptible to infection. See Table 6–6, *Bean Disease Control Recommendations*, on page 67.

VIRUSES (BEAN COMMON MOSAIC, BEAN YELLOW MOSAIC, CUCUMBER MOSAIC)

Symptoms: Leaves develop patches of light- and dark-green discolouration. They may also become puckered and twisted. Plants are often stunted, with poor seed set and misshapen pods. Bean yellow mosaic may also produce bright yellow spots on the leaf tissue.

Table 6–6.
Bean Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Bacterial Blight (Halo and Common)						
copper hydroxide	inorganic	Parasol WP	2.25–3.25 kg	1–1.3 kg	1	
Grey Mould (Botrytis), White Mould (Sclerotinia)[2]						
vinclozolin	dicarboximide	Ronilan EG	1.0–1.5 kg	0.4–0.6 kg	14	Spray at first bloom. Maximum 2 applications/yr.
dicloran	quinone	Botran 75 W	3.25 kg	1.3 kg	2	Spray at first bloom. Do not feed treated foliage to livestock.
iprodione	dicarboximide	Rovral	1.5 kg	0.6 kg	15	Spray at 50% bloom. Aerial application permitted.
boscalid	Group 7	Lance WDG	560–770 g	224–308 g	7	Spray at 20%–50% bloom Maximum 2 applications per season. Use 420 g/ha (168 g/ac) for grey mould control.
Pythium Damping-Off, Phytophthora Root Rot						
metalaxyl-M	acylamine	Ridomil Gold 480 EC	300 mL[3]	120 mL[3]		Snap beans only. Apply only once per year at planting.

[1] DHI = Days to Harvest Interval
[2] For snap beans grown in fields recently affected by sclerotinia white mould.
[3] Based upon 2.3 mL per 100 m (328 ft) of row using a 20-cm (8-in.) spray band and a 76-cm (30-in.) row spacing.

Development: These viruses are spread by aphids and usually follow periods of high aphid activity.

Management Notes: Bean common mosaic is also seed-borne. Select resistant varieties where possible. Bean yellow mosaic overwinters in red clover and alfalfa fields. If possible, avoid planting beans near perennial forage crops.

Insects

SEEDCORN MAGGOTS, WIREWORMS, TARNISHED PLANT BUG, APHIDS

For identification and management information on these common vegetable insects affecting beans, see *General Insects and Diseases of Vegetable Crops*, on page 54, Table 6–5, *Bean Seed Treatments*, on page 66, and Table 6–7, *Bean Insect Control Recommendations*, on page 68.

POTATO LEAFHOPPER

Identification: The adult leafhopper is yellow-green, wedge-shaped and approximately 3 mm long. Immature nymphs are smaller and wingless. When disturbed, leafhoppers quickly move forward or sideways. Both the adults and the nymphs feed on beans, causing leaf puckering and browing of the leaf margins (also known as "hopperburn"). Hopperburn is often confused with drought stress.

Period of Activity: Leafhoppers migrate to Ontario in early spring. Initial generations feed on alfalfa before moving into bean crops. Plants are most susceptible to feeding-damage prior to bloom. Low levels of feeding on newly emerged seedlings can have a severe impact on yield.

Thresholds: A spray is warranted if there are more than 2 adults per 0.3 m (1 ft) of row at the seedling stage. For later crop growth stages, the threshold is 5 adults per 0.3 m (1 ft) of row. For nymphs, the threshold is 10 nymphs per 100 leaves (at any crop stage).

Management Notes: See Table 6–7, *Bean Insect Control Recommendations*, on page 68. Monitor the crop closely at first cut where beans are planted in the vicinity of an alfalfa field.

EUROPEAN CORN BORER

Identification: Full-grown corn borer larvae are 2.5 cm (1 in.) in length. They are a greasy white colour, with spots and a dark head. Eggs are shiny, white and laid in clusters of 30 that resemble fish scales. Corn borer larvae feed briefly on the leaves but soon begin tunnelling into the stems and pods. Since much of the pod damage is internal with only a small entry hole visible on the outside, grading-out infested pods is very difficult.

Period of Activity: Borers overwintering in corn stubble become active as soil temperatures consistantly exceed

Table 6–7.
Bean Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aphids						
dimethoate[2]	organophosphate	Cygon 480[2]	0.7–1 L	0.28–0.4 L	7	Snap beans only.
		Lagon 480[2]	0.7–1 L	0.28–0.4 L	7	Aerial application permitted. Maximum 3 applications per year.
malathion	organophosphate	Malathion 500 E	1.5–2.75 L	0.6–1.1 L	3	
naled	organophosphate	Dibrom	1.1–2.2 L	0.44–0.88 L	4	Lima beans only. Aerial application permitted. Do not apply when temperature is >32°C (90°F).
Corn Borer						
permethrin	pyrethroid	Pounce	260 mL	104 mL	7	Aerial application permitted. Maximum 2 aerial applications per season.
methomyl	carbamate	Lannate	550 g	220 g	7	Minimum period for re-entry is 24 hours.
Bacillus thuringiensis	biological	Bioprotec CAF	2.8–4.0 L	1.1–1.6 L	1	Maximum 4 applictions per season. Allow 5–10 days between applications.
spinosad	naturalyte	Success 480 SC	83 mL	33 mL	7	Use only on small larvae and low infestations.
Leafhoppers, Mexican Bean Beetle						
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1 L	5	Use low rate on young plants. Use high rate for leafhoppers.
endosulfan[2]	chlorinated cyclodiene	Thiodan 4 EC[2]	1.5–2.5 L	0.6–1 L	2	**Do not** apply on lima beans. Also controls green cloverworm.
dimethoate[2]	organophosphate	Cygon 480[2]	0.7–1.0 L	0.28–0.4 L	7	Also controls tarnished plant bug.
		Lagon 480[2]	0.7–1.0 L	0.28–0.4 L	7	
malathion	organophosphate	Malathion 500 E	1.5–2.75 L	0.6–1.1 L	3	Mexican bean beetle only.
Slugs						
ferric phosphate	inorganic	Sluggo	25–50 kg	10–20 kg	0	Use higher rates on severe infestations.
Spider Mite						
dicofol[2]	diphenylethane	Kelthane 50 W[2]	1.0–1.25 kg	0.4–0.5 kg	7	Apply only once/season. Use high rate on larger plants.

[1] DHI = Days to Harvest Interval
[2] Do not graze or feed treated foliage to livestock.

10°C (50°F). Southwestern Ontario experiences two generations per year, while the rest of the province has only one. Beans are susceptible to damage from flowering through pod development.

Thresholds: None established.

Management Notes: Where beans follow corn in rotation, consider disking the corn residue to reduce overwintering borer populuations. Borers are most likely to be a pest in snap beans when other host plants are not available (early season, before corn is attractive, or late season, after the corn has dried down.) For control options, see Table 6–7, *Bean Insect Control Recommendations*, above.

For more information, see the OMAF Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

MEXICAN BEAN BEETLE

Identification: Both the adult and the larvae Mexican bean beetles are occasional pests of snap bean in Ontario. The adults are coppery-red, oval and approximately 6 mm (¼ in.) in length with 16 black spots on the wing casings. They resemble ladybugs. The larvae are yellow with rows of long, black-tipped spines along their backs.

Period of Activity: Adults emerge from overwintering sites (grassy fencerows and wooded areas) in early May.

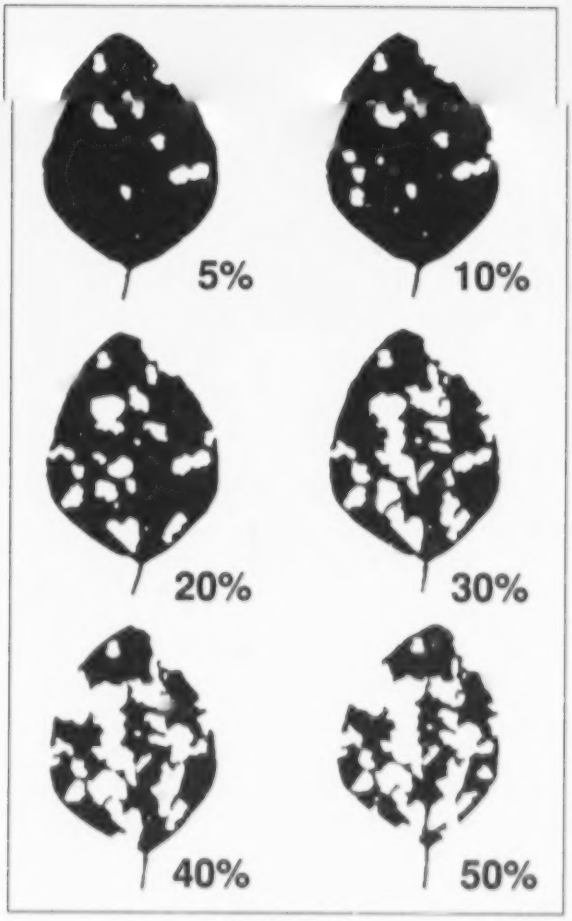

Figure 6–1.
Defoliation Chart for Soybean Leaf-Feeding Insects
Source: University of Illinois and Purdue University, 1982.

Eggs are laid and feeding continues for approximately one month. There are one-to-two generations per year.

Thresholds: Chemical controls may be required if leaf defoliation exceeds 20% prior to bloom and 10% during pod-fill. See Figure 6–1, *Defoliation Chart for Soybean Leaf-Feeding Insects*, above. Excessive defoliation from this pest will result in early maturity and yield losses.

Management Notes: See Table 6–7, *Bean Insect Control Recommendations*, on page 68. Border sprays may be an effective way to control the beetles as they move out of the fencerow.

TWO-SPOTTED SPIDER MITES

Identification: The adult mite is approximately 0.5–1 mm in length and is barely visible to the naked eye. They are a translucent yellowish colour with two dark spots on the sides of their abdomen. Spider mites feed on individual cells through sucking mouth parts. Injury first appears as a bronzed, stippled effect. Severe feeding causes curling and drying of the leaves. Symptoms are often confused with drought stress.

Period of Activity: Mite activity is most common in hot, dry conditions. They often move into bean crops following wheat harvest.

Thresholds: Populations prior to pod fill are the greatest cause for concern. Spray if there are 4 or more mites per leaf or one severely damaged leaf per plant.

Management Notes: Heavy rain or overhead irrigation often reduces mite levels to below threshold. See Table 6–7, *Bean Insect Control Recommendations*, on page 68.

Physiological Disorders

Bronzing

Bronzing is a physiological disorder caused by high levels of atmospheric ozone associated with air pollution. It usually occurs following the initiation of flowering and after the older leaves become fully mature. A bronze-coloured stipple develops on the pods and the upper surface of the leaves. Pod and seed set are usually reduced, and the plants age prematurely. Dry beans and limas appear more sensitive than snap beans; cultivars within these types differ in susceptibility.

Storage

Store fresh market snap beans at 4°C–7°C (39°F–45°F) and a relative humidity of 95%. Under good conditions, beans will store for 7–10 days. If possible, keep lima beans at slightly lower temperatures.

BEETS, TABLE

Production Requirements

Beets prefer a well-drained, loamy soil. They can also be grown successfully on well-drained muck soils. Emergence will be poor on heavy soils or those prone to crusting. A soil pH of 6.8–7.8 is ideal. Beets require from 55–80 days from seeding to harvest for fresh market and from 90–110 days for processing crops.

Beets are frost tolerant. The best colour and quality are obtained when they are grown during cool temperatures: 13°C–21°C (55°F–70°F). Heavy rains following a hot, dry period or extended periods of high temperature will cause poor colour.

Average Yields

Crop	per acre	per hectare
Fresh market beets	400–600 50-lb bags	1,000–1,500 50-lb bags
Processing beets	15–20 tons	34–45 tonnes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Field Seeding and Spacing

For a continuous supply of beets for bunching, sow seed at 2-week intervals, from early April to the end of July. For storage and processing, sow about 10 weeks before late-fall harvesting. Seed will not germinate at temperatures lower than 4°C (39°F). The optimum germination temperature is from 10°C–29°C (50°F–84°F.)

Row spacing:	30–40 cm (12–16 in.)
Rate:	7 kg/ha (6 lb/ac)
Depth:	1.2–2.0 cm (½–1 in.)

Thin plants 5–8 cm (2–3 in.) apart. No thinning is required on muck soils when seeders are adjusted to ensure a stand of 32–40 plants/m of row (10–12 plants/ft of row).

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Table 6–8.
Table Beet Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral Soils		
Preplant	65	58
Side-dress	45	40
Total	**110**	**98**
Muck Soil		
Preplant	40	36

Broadcast and incorporate all the recommended preplant nitrogen along with the recommended potash and phosphate. On mineral soils, apply the remainder of the nitrogen as a side-dress application. See Table 6–8, *Table Beet Nitrogen Recommendations*, above.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

If phosphate and potash are required, they should be applied and incorporated prior to planting.

Micronutrients

BORON

Boron deficiency shows up as a breakdown and corky, dark discolouration of internal tissues. It is most likely to occur on alkaline soils after prolonged hot, dry periods. See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

MANGANESE

Deficient plants show marked yellowing between the leaf veins; the veins themselves remain green. To correct a deficiency, spray with manganese sulfate. See the section *Manganese*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Table 6–9.
Table Beet Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL LS	metalaxyl-m	20–40 mL per 100 kg seed	damping-off	Export use only. For use in commercial seed treatment plants only.
Thiram 75 WP	thiram	90 g per 25 kg seed	damping-off	

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information on these common vegetable diseases affecting table beets, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. Also see Table 6–9, *Table Beet Seed Treatments*, above.

CERCOSPORA LEAF SPOT

Identification: Look for numerous small, circular lesions with a dark-brown-to-purplish halo on the leaves. Small black dots can be seen with a hand lens in the centre of the lesions. The centres may turn grey and fall out, leaving a ragged appearance. This disease can lead to defoliation and reductions in yield.

Development: Mid-July through early September. Air temperatures above 24°C (75°F) with extended periods of leaf wetness due to rain, heavy dews or fog are favourable for cercospora development.

Thresholds: None established. Monitor for the appearance of leaf lesions.

Management Notes: This disease is more of a problem on fresh, bunched beets. If monitoring indicates a need, apply fungicide as indicated in Table 6–10, *Table Beet Disease and Insect Control Recommendations*, on page 72.

POCKET ROT/ROOT ROT (RHIZOCTONIA)

Identification: Symptoms vary from cankers on lower petioles and crowns to root rot of beets.

Development: This disease is more severe when long periods of wet conditions prevail. It is most active at temperatures of 25°C–33°C (77°F–91°F).

Thresholds: None established.

Management Notes: Avoid throwing soil onto beet roots while cultivating. Rotate with grain crops. Management practices aimed to improve drainage and soil structure should reduce disease severity.

Insects

WIREWORMS, CUTWORMS, APHIDS

For identification and management information on these common vegetable insects affecting table beets, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–10, *Table Beet Disease and Insect Control Recommendations*, on page 72.

LEAF MINERS

Identification: Look for the presence of tunnels or "mines" inside the leaves. Eggs are laid on the underside of leaves.

Development: Throughout the season.

Thresholds: None established. Scout for mines or for eggs on the underside of leaves.

Management Notes: Leaf miner control is usually required only for bunching beets, where damage-free tops are required.

BEET WEBWORM

The larvae are dark-coloured, with yellow stripes along the body. They produce webs on leaves and petioles. Webworms are usually only a minor problem in Ontario. On bunched beets, treatment may be warranted if more than 3%–6% of the plants are infested.

Nematode Control

To avoid damage from sugar-beet cyst nematode, do not plant beets following rhubarb, spinach, beets or cruciferous crops. Rotation to non-cruciferous crops for 4–5 years will significantly reduce populations of this nematode. See the section *Nematodes*, on page 57.

Table 6–10.
Table Beet Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cercospora Leaf Spot						
copper sulfate	inorganic	Copper 53 W	4 kg	1.6 kg	1	
pyraclostrobin	strobilurin	Cabrio EG	560–840 g	220–330 g	3	Maximum 2 sequential applications. Maximum 3 applications.
Cutworms						
permethrin	pyrethroid	Pounce	180–390 mL	73–155 mL	Up to 5-leaf stage	Use higher rates on muck or dry soils.
Aphids						
dimethoate	organophosphate	Cygon 480	700 mL	280 mL	12	Beet greens only.
diazinon[2]	organophosphate	Diazinon 500 E	1.1 L	0.44 L	14	
		DZN 600 EW	915 mL	370 mL	14	
malathion[18]	organophosphate	Malathion 25 W	2.25–5.5 kg	0.9–2.2 kg	7	
		Malathion 500 E	1.8–2.5 L	0.7–1.0 L	3	
Leafhoppers						
dimethoate	organophosphate	Cygon 480	700 mL	280 mL	12	Beet greens only.

[1] Days to Harvest Interval.
[2] Control of aphids with diazinon and malathion has been inconsistent in many areas.

Harvest and Storage

Harvest begins in late August and can continue through fall frosts. It must be completed before a hard freeze.

Mature topped beets may be stored for 4–6 months at close to 0°C (32°F) and 98%–100% relative humidity. Do not allow the beets to freeze.

CARROTS

Production Requirements

Carrots are cool-season vegetables. They grow best in deep, well-drained muck and sandy loam soils. Carrots are extremely sensitive to environmental conditions such as heat, soil compaction, water stress and saturation. Continuous high temperatures in the latter stages of plant development may reduce yield, retard growth and produce a strong-flavoured, coarse root. Temperatures below 16°C (61°F) also slow plant growth.

Carrots are planted between mid-April to mid-June to avoid excessive heat. Most carrot varieties mature in 120–180 days. Fresh-market carrots are harvested late-July through October. Processing carrots are harvested October through November.

Average Yields

Crop	per acre	per hectare
Processing	35–40 tons	78–90 tonnes
Fresh market	15–20 tons	34–45 tonnnes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Fresh market: 2–4.5 kg/ha (1.8–4 lb/ha)

Processing: 1–2 kg/ha (0.9–1.8 lb/ha)

Sow as early as soil and weather conditions permit in the spring, up to July 1. Late carrots may "burn off" if they emerge during hot, dry weather. Seed into moisture, 1.2–2 cm (0.5–0.8 in.) deep.

Sowing carrots on raised beds, 15–20 cm (6–8 in.) high, improves carrot quality. Beds that are 85 cm (34 in.) wide at the bottom and 50 cm (20 in.) wide on top have yielded good results. Seed carrots in 3 or 4 rows on the centre of the bed at a rate to achieve 26 carrots/m (26 carrots/40 in.) for processing carrots and 120–140 carrots/m (120–140 carrots/40 in.) for fresh-market carrots.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and

Table 6–11.
Carrot Nitrogen Recommendations

Soil	Actual N	
	kg/ha	lb/ac
Mineral Soils		
Preplant	70	62
Side-dress	40	36
Total	**110**	**98**
Muck Soils		
Preplant	60	53

Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.

Broadcast and incorporate the recommended preplant nitrogen with all the required phosphate and potash. On mineral soils, apply side-dress nitrogen when the plants are 10 cm (4 in.) tall.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.) If phosphate and potash are required, they should be applied and incorporated prior to planting.

Magnesium

Magnesium deficiency may occur on carrots. The usual symptoms are yellowing of older leaves while the veins remain dark green. See the section *Magnesium*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Micronutrients

BORON

Boron deficiency can cause necrosis in the growing tip or internal breakdown in carrot roots. Boron is often recommended on new muck soils. Use caution when applying boron. This nutrient can build to toxic levels quite quickly. Various sources of boron are available. See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Table 6–12. Carrot Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL LS	metalaxyl-m	20–40 mL per 100 kg seed	damping-off and root rot	For use in commercial seed treatment plants only. Export use only.
Rovral	iprodione	521 mL per 100 kg seed	seed-borne alternaria	For imported seed only.

COPPER

Copper (Cu) deficiency may occur on acid peat and muck soils resulting in carrot roots with poor orange colour. Apply 14–29 kg Cu/ha (12.5–26 lb/ac) on newly cultivated muck soils. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. See the section *Copper* and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

OMAF Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, provides a comprehensive guide to IPM for carrots.

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information on these common vegetable diseases, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. Also see Table 6–12, *Carrot Seed Treatments*, above.

LEAF BLIGHTS

Identification: Two different fungi (*Alternaria dauci* and *Cercospora carotae*) and one type of bacteria (*Xanthomonas campestris*) cause leaf blights in carrots. *Alternaria* produces irregular brown spots (often surrounded by yellowish halos) along the edges of carrot leaves only. *Cercospora* causes circular grey or brown lesions on both leaves and petioles. Dark-brown lesions with an irregular yellow halo characterize *Xanthomonas*.

Development: Both *Alternaria* and *Cercospora* fungi overwinter in the crop residue of infected carrots. Their spores are dispersed by wind. All three diseases are favoured by warm, humid conditions in the 20°C–30°C (68°F–86°F) range. Symptoms usually appear 10 days after infection.

Thresholds: Apply protectant fungicides when blight is first detectable (on 1%–2% of the leaf area.)

Management Notes: After the initial fungicide application, a recommended fungicide should be applied at 7–10-day intervals when weather is favourable for blight. The intervals between sprays are extended when the weather is unfavourable for blight. After the leaves have closed over the rows, spray at 7–10-day intervals.

See Table 6–13, *Carrot Disease Control Recommendations*, on page 75.

ROOT DIEBACK, RUSTY ROOT, CAVITY SPOT

Identification: A variety of symptoms may result from attacks of *Pythium* fungi including leaf wilting and discolouration, deformed roots (short, stuffy, forked), rusty red roots and the formation of fibrous roots. Dark, oval lesions on the surface of the carrot root characterize cavity spot.

Development: *Pythium* is a persistent, soil-borne fungus that likes wet soils. Cavity spot lesions usually start to appear in August and September and may slowly enlarge while carrots are in storage.

Thresholds: None established.

Management Notes: Grow resistant cultivars, avoid problem fields and grow carrots on raised beds. See Table 6–13, *Carrot Disease Control Recommendations*, on page 75.

CROWN ROT, VIOLET ROOT ROT

Identification: Foliar symptoms of crown rot and violet root rot tend to appear in patches. Plants become stunted and yellow followed by wilting and death of the foliage. Root symptoms do not show up until the carrot is mature. Crown rot produces large, grey-brown lesions near the top of the carrot root. Violet root rot covers the root with a thick, purplish fungal layer. When the carrots are pulled, a considerable amount of soil adheres to them.

Development: Appears during mid summer.

Management Notes: The only practical control is to avoid infected areas, rotate for several years with grains and practice strict sanitation procedures to avoid spreading infected soil between fields.

Table 6–13.
Carrot Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Leaf Blight						
mancozeb	dithiocarbamate	Manzate 200 DF	2.25 kg	0.9 kg	7	Do not feed treated tops to livestock.
		Dithane	2.25 kg	0.9 kg	7	
		Penncozeb 30 WP	2.25 kg	0.9 kg	7	
zineb	dithiocarbamate	Zineb 80 W	2.75 kg	1.1 kg	7	
chlorothalonil	chloronitrile	Bravo 500	2.4–3.2 L	1.0–1.3 L	1	
metiram	dithiocarbamate	Polyram DF	2.25 kg	0.9 kg	7	Do not feed treated tops to livestock.
pyraclostrobin	strobilurin	Cabrio EG	0.56–1.1 kg	0.22–0.44 kg	3	**Alternaria Leaf Blight** Maximum 2 sequential applications. Maximum 3 applications.
boscalid	anilid	Lance WDG	315 g	126 g	0	**Alternaria Leaf Blight** Maxiumum 2 sequential applications. Max 5 applications per season.
Cavity Spot						
metalaxyl	acylamine	Ridomil 2G	25 kg	10 kg		215 g/100 m of raised bed. Apply product evenly with seed in the furrow.

[1] DHI = Days to Harvest Interval.

SCLEROTINIA WHITE ROT

Identification: Sclerotinia white rot is typically a disease of stored carrots. The disease comes from the field and may infect plants before harvest. In storage, infected roots develop a growth of white, cottony fungi and small black sclerotia. The fungus can quickly spread to healthy carrots while in storage. Infection in the field starts at the base of the leaf stalk, causing the petiole to turn brown and die.

Development: Optimum temperatures for infection are 15°C–20°C (59°F–68°F). However, sclerotinia white rot can still spread in storage as long as the temperatures are above 0°C (32°F). Development of the disease in the field occurs under cool, wet conditions. It overwinters in crop residue and as hard, black sclerotia, which can survive in the soil for many years.

Management Notes: Rotate with onions, beets or spinach for 2–3 years. Use wider row spacings to encourage good air movement. Initial infection of storage carrots is less likely to occur if the relative humidity is less than 92% and the field heat is removed as quickly as possible.

ASTER YELLOWS

The symptoms of aster yellows on carrots first appear as a reddening of several leaves. Crown growth becomes yellow and brittle, followed by hairy root development. Aster yellows is transmitted by the aster leafhopper. See the section *Aster Leafhopper*, below.

For more information, see the following OMAF Factsheets:

- *Identification and Management of Carrot Root Diseases*, Order No. 98-001
- *Management of Carrot Leaf Diseases*, Order No. 00-045

Insects

CUTWORMS, WIREWORMS

For identification and management information on these common vegetable insects affecting carrots, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–14, *Carrot Insect Control Recommendations*, on page 76.

ASTER LEAFHOPPER

Identification: These small, greenish-grey insects feed on a wide range of plants, especially grasses, grains and vegetables.

Period of Activity: As the winter grains mature in late May and early June, local first-generation leafhoppers disperse to vegetable crops. Migration of leafhoppers from the US into Ontario may also take place. Migrations into Ontario are not consistent from year to year, because leafhopper move-

Table 6–14.
Carrot Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aster Leafhopper						
carbaryl	carbamate	Sevin XLR Plus	1.25–2.5 L	0.5–1.0 L	1	Use low rate on young plants.
Carrot Weevil						
phosmet	organophosphate	Imidan 50 WP	2.25 kg	0.9 kg	40	Maximum 2 applications/yr.
Carrot Rust Fly						
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	112 mL	35	Maximum 3 applications/yr.
		Ripcord 400 EC	175 mL in 550 L water	70 mL in 220 L water	35	Maximum 3 applications/yr.
diazinon	organophosphate	Diazinon 50 W	1.0 kg	0.4 kg	10	
		DZN 600 EW	915 mL	366 mL	10	
Cutworms[2]						
chlorpyrifos	organophosphate	Lorsban 4E	2.4–4.8 L	0.96–1.9 L	60	24-hr re-entry period. Use high rate on large larvae or dry soils.
		Pyrinex 480 EC	2.4–4.8 L	0.96–1.9 L	60	24-hr re-entry period. Use high rate on large larvae or dry soils.
permethrin	pyrethriod	Pounce	180–390 mL	72–156 mL		Use high rate on muck soils, large larvae or dry soils. Do not disturb soil for 5 days after application.
cypermethrin	pyrethriod	Ripcord 400 EC	175 mL	70 mL	21	Do not disturb soil for 5 days after application.

[1] DHI = Days to Harvest Interval.
[2] Seedling treatments.

ments are regulated by wind and weather patterns. Both local dispersal and long-distance migration influence the incidence and severity of the aster leafhopper.

Thresholds: An Aster Yellows Index (AYI) determines the need to treat a crop. To use the AYI, monitor aster leafhoppers with a sweep net. Multiply the number of aster leafhoppers captured in 100 sweeps by the percentage of leafhoppers carrying aster yellows in your area (4%–5% is the currently recommended percent infectivity in Ontario). Use this formula:

Infectivity rate (4%–5%) x # of leafhoppers (per 100 sweeps) = AYI

Treat when the AYI exceeds:

Carrot Tolerance[1]	Aster Yellows Index
Resistant	100
Intermediate	70
Susceptible	50

[1] If a carrot variety has not be evaluated for aster yellows tolerance, use an AYI of 70 as a guideline.

Management Notes: Grow resistant cultivars and remove perennial weeds from fields that may act as reservoirs. See Table 6–14, *Carrot Insect Control Recommendations*, above.

CARROT RUST FLY

Identification: The adult rust fly is shiny and black, measuring approximately 6 mm (¼ in.) in length. It has an orange head, brown eyes and pale, yellow legs. The larva is cream-white and legless with dark mouthhooks. Hatching larvae feed on the root hairs for up to a month before tunnelling into the carrot, where they continue feeding. Feeding damage from rust fly larvae is usually limited to the lower two-thirds of the root.

Period of Activity: The carrot rust fly overwinters as a pupa in the soil and usually has two generations per year. The first generation often coincides with lilac bloom, the second begins in mid-August. Occasionally, sufficient heat units are accumulated so that a third generation emerges in late September or October. This third generation occurs too late in the season to have any serious effect on the crop.

Thresholds: Control adults if populations reach a level of 0.1 flies/trap/day (fresh market) or 0.2 flies/trap/day

(processing). Rust flies are no longer a concern once the crops is within 21 days of harvest.

Management Notes: Crop rotation will reduce background populations. Consider late seeding to avoid the first-generation damage. Avoid growing carrots in sheltered areas where rust flies are more prevalent.

See Table 6–14, *Carrot Insect Control Recommendations*, on page 76.

CARROT WEEVIL

Identification: The carrot weevil adult is a dark-brown snout beetle (6 mm (¼ in.) long). It overwinters in the plant debris of previously infested fields. Feeding damage commonly occurs in the upper third of the root. Developing larvae tunnel into young, slender roots, causing the plants to wilt and die.

Period of Activity: The adult females do not attack carrots prior to the first true leaf. Egg-laying occurs from mid-May to early June. Eggs hatch in 1–2 weeks, and larvae feed for at least 3 weeks after emergence. Adults will emerge 2 weeks later. A second generation may occur on early carrot crops under warm weather conditions.

Thresholds: A Growing Degree Day (GDD) model for egg-laying has been developed at base 7°C (45°F). First egg-laying is expected at 147 GDD, which occurs from mid-May to early June. Expect 90% egg-laying at 455 GDD. For more information on GDD models, see the section *Growing Degree Days*, on page 38.

Management Notes: Time treatments to control adults prior to egg-laying. Crop rotation and weed control around field edges may reduce overwintering populations. The egg parasite *Anaphes sordidatus* (a small braconid wasp) provides some biological control. See Table 6–14, *Carrot Insect Control Recommendations*, on page 76.

For more information, consult the following OMAF Factsheets and publication:

- *Carrot Insects*, Order No. 93-077
- *The Aster Leafhopper and Aster Yellows*, Order No. 98-057
- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*

Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 57.

Storage

Mature topped carrots can be stored for up to 4–5 months at 0°C (32°F) and a relative humidity of 90%–98%. Rapid cooling of carrots after harvest is very important for reducing storage rots.

Proper sanitation of the storage and handling equipment will also help reduce storage losses. See the section *Storage Sanitation*, on page 49, for information on sanitation of storage.

See the OMAF Factsheet, *Long-Term Storage of Carrots*, Order No. 98-073.

CELERY

Production Requirements

Celery is a cool-season vegetable. Muck soils, with high water-holding capacity are ideal for production. Irrigated celery may be grown successfully on well-drained mineral soils. Celery can withstand light frosts, but the crop may be damaged if temperatures remain below 0°C (32°F) for a prolonged period of time. Premature seed stalk development or "bolting" may occur if young plants are exposed to temperatures below 13°C (55°F) for 10 days or more.

Most celery varieties mature in 80–90 days after transplanting. Celery harvest begins in late July and continues until several frosts have occurred.

Average Yields

Crop	per acre	per hectare
Processing	20–30 tons	45–68 tonnes
Fresh market	750–1,000 60-lb cartons	2,200 60-lb cartons

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Spacing

Row width: 50–55 cm (20–22 in.)

In-row spacing: 15 cm (6 in.)

Rate: approx. 140 g of seed/ha (56 g/ac)

Early celery is started from seed in a greenhouse at the beginning of February. If row covers are used, transplanting can occur as early as April 1. Seeding continues through June 1 for July transplanting. Plants for the late crop may be started in irrigated, outdoor seedbeds.

Direct-seed transplant beds in rows 15–20 cm (6–8 in.) apart, at a rate of 80–110 seeds/m of row (24–34 seeds/ft). The stand will not need thinning before transplanting to the field. Seed may also be broadcast onto a finely prepared bed at a rate of 15 g per 10 m^2. However, the first method provides sturdier plants.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application (see Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24). Table 6–15, *Celery Nitrogen Recommendations*, above, shows nitrogen recommendations for mineral and muck soils.

Table 6–15.
Celery Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral Soils[1]		
Preplant	135	120
Side-dress	30[2]	27
Total	**195**	**174**
Muck Soils[1]		
Preplant	80	71
Side-dress	40	35
Total	**160**	**142**

[1] Broadcast and incorporate recommended preplant nitrogen with all of the required phosphate and potash.
[2] Up to 2 applications.

Broadcast and incorporate recommended preplant nitrogen with all the required potash and potassium.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

Broadcast and incorporate phosphate and potash requirements prior to planting.

Secondary Nutrients and Micronutrients

CALCIUM

Calcium deficiency results in a physiological disorder known as "black heart." The celery heart turns black, while the outer leaves are unaffected. If celery is under heat and moisture stress, weekly foliar calcium sprays directed into the heart of the plant may reduce black heart symptoms. See the section *Calcium*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

MAGNESIUM

Magnesium deficiency appears as chlorosis between the dark green veins of the older leaves. Some celery cultivars are inefficient at taking up magnesium from the soil.

Table 6–16.
Celery Blight Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
mancozeb	dithiocarbamate	Dithane	2.25 kg	0.9 kg	14	Wash and trim.
		Manzate 200 DF	2.25–3.25 kg	0.9–1.3 kg	14	Wash and trim.
		Penncozeb 80 WP	2.25 kg	0.9 kg	14	Wash and trim.
metiram	dithiocarbamate	Polyram DF	2.25–3.25 kg	0.9–1.3 kg	14	After transplanting only.
zineb	dithiocarbamate	Zineb 80 W	2–3 kg	0.8–1.2 kg	14	
copper sulphate	inorganic	Copper 53 W	3.25–6.5 kg	1.3–2.6 kg	1	Use higher rates as crop increases in size.
copper oxychloride	inorganic	Copper Spray	4.0 kg	1.6 kg	1	
chlorothalonil	chloronitrile	Bravo 500	1.6–2.4 L	0.6–0.96 L	7	On a 3–5-day schedule.
			2.4–4.0 L	0.96–1.6 L	7	On an 8–10-day schedule.

[1] Days to Harvest Interval.

Where soil magnesium levels are low, apply foliar sprays starting when the plants are about one-third grown. See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

BORON

Boron deficiency results in a physiological disease known as "cracked stem" or "cat scratches." See Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

OMAF Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, provides a comprehensive guide to IPM for celery.

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information on these common vegetable diseases, see the section *General Insects and Diseases of Vegetable Crops*, on page 54.

Seed Treatment

Buy hot-water-treated seed or sow 3-year-old seed to avoid seed-borne blight fungi. Use seed treated with thiram (dithiocarbamate group) to help prevent damping-off, seedling blight and seed decay. Use 90 g of Thiram 75 WP for every 25 kg (55 lb) of seed.

EARLY BLIGHT, LATE BLIGHT AND BACTERIAL LEAF SPOT

Identification: The symptoms for all three diseases include small yellow specks or lesions on the leaves. Older lesions frequently turn tan-to-brown coloured. Early and late blight lesions may enlarge to 1 cm or more in diameter. Under heavy bacterial leaf spot pressure, lesions will merge and kill infected leaves.

Development: Early blight occurs during mid-summer when heavy evening dews follow sunny, warm, daytime weather. Late blight starts in the lower foliage and moves upwards. All three of these diseases overwinter in crop residue. Following the initial infection, spores are further dispersed by splashing water and the wind.

Thresholds: None established.

Management Notes: If the field has a history of blights, rotate away from celery for at least 2 years. Use hot-water-treated seed and resistant varieties. Grow seedlings in a commercial soilless mix or heat-pasteurized soil. Rotate outdoor seedbeds. Do not transplant diseased seedlings into the field.

Begin a protectant program when the seedlings are about 5 cm high. Apply one or two applications before transplanting (see the section *Vegetable Transplants*, on page 175). After transplanting, begin fungicide application when plants are one-third grown or when the first signs of disease are detected. See Table 6–16, *Celery Blight Control Recommendations*, above.

FUSARIUM YELLOWS

Identification: Infected plants are often stunted and may be greenish-yellow in colour. The fungus infects the root and basal plate. It causes a darkening of the vascular tissues, followed by basal rot and plant death.

Development: This fungus persists in soil for many years. Fusarium yellows may be introduced by infected transplants, on soil carried by wind or water erosion and by workers or equipment.

Management Notes: Sanitation is important in preventing the spread of this disease. Avoid cultivation practices that can spread infested soil from one area to the rest of the field. Do not return infested celery trimmings to fields after harvest. Practice a 2- to 3-year rotation with onions or lettuce to reduce spore populations in infested fields. Avoid the use of carrots in the rotation.

Tolerant varieties will withstand moderate levels of the fungus. High fungal populations, excessive heat and drought stress may diminish this tolerance.

PINK ROT (SCLEROTINIA)

Identification: The *Sclerotinia* fungi cause damping-off of seedlings. Infected celery plants develop a pink or reddish-brown water-soaked area on the petioles or stalks. Hard black sclerotia may also be present. Under severe conditions, secondary infections may occur, causing the plant to collapse.

Development: Pink rot is an occasional problem during wet seasons.

Management Notes: Wider row spacings will facilitate airflow and reduce the chance of infection. Where infection has occurred, rotate to onions or another non-susceptible crop. *Sclerotinia* also causes white mould in carrots.

CUCUMBER MOSAIC VIRUS (CUMV)

Identification: Symptoms in celery are a mosaic pattern on the leaf, accompanied by downward curling of the petioles. A greenish-yellow discolouration develops along the veins. There may be some crinkling of leaves. Brown, irregularly shaped, sunken lesions also form on the petioles as the virus develops.

Development: This virus is spread by aphids and usually follows periods of high aphid activity.

Management Notes: Control weeds bordering the crop area. Rogue out infected plants if mosaic symptoms are noticed early in the season. See the section *Aphids*, on page 54.

ASTER YELLOWS

Identification: Symptoms on celery first appear as a bright yellowing of several leaves. Excessive, brittle, yellow crown growth, severe twisting and secondary bacterial infections follow. Roguing out infected plants is an effective way to reduce in-field sources of diseases. Aster yellows are transmitted by the aster leafhopper. See the section *Aster Leafhoppers*, below.

For more information, see the following OMAF Factsheets and publication:

- *Identification and Management of Celery Leaf Blights*, Order No. 00-093.
- *Fusarium Yellows of Celery*, Order No. 89-180.
- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*

Insects

APHIDS, CUTWORMS, TARNISHED PLANT BUG

For identification and management information on these common vegetable insects affecting celery, see the section *General Insects and Diseases of Vegetable Crops*, on page 54.

ASTER LEAFHOPPERS

See the Aster Yellows Index (AYI) calculation in the section *Aster Leafhopper*, on page 75.

For celery, treat when the AYI equals 30–35. See Table 6–17, *Celery Insect Control Recommendations*, on page 81.

LEAF MINERS

Identification: The pea leaf miner (PLM) has been found in the Holland Marsh area of Ontario. Adults are small, black-to-grey flies with yellow markings. Eggs are laid in the leaves, leaving small "bronzed" puncture marks. Females pierce the leaves to feed on plant sap. Larvae feed between the upper and lower surface of the leaves, creating relatively straight mines that usually follow the veins. Other leaf miners tend to make curved, serpentine mines.

Leaf miner feeding reduces the plant's photosynthetic capacity. The mines also affect marketability and provide an entrance for disease organisms.

Table 6–17.
Celery Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aster Leafhopper						
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL	56 mL	7	Maximum 3 applications per season.
malathion	organophosphate	Malathion 500 E	2.25 L	0.9 L	7	
carbaryl	carbamate	Sevin XLR Plus	1.25–2.5 L	0.5–1 L	5	
Carrot Weevil						
phosmet	organophosphate	Imidan 50 WP	2.25 kg	0.9 kg	40	Maximum 2 applications per season.
Tarnished Plant Bugs						
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	0.7 kg	14	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	0.8 L	14	
		Endosulfan 50W	1.75 kg	0.7 kg	14	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	21	Maximum 4 applications/yr.
Aphids						
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	0.7 kg	14	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	0.8 L	14	
		Endosulfan 50W	1.75 kg	0.7 kg	14	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	21	Green peach aphid only.
pirimicarb	carbamate	Pirimor 50 DF	300–500 g	120–200 g	10	Maximum 4 applications/yr.
acetamiprid	chloronicotinyl	Assail 70 WP	56–86 g	22.4–34.4 g	7	Maximum 5 applications/yr. Alternate applications with other insecticide families.
Cabbage Looper						
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.75 kg	0.7 kg	14	Trim the celery of all outer leaves.
		Thiodan 4 EC	2.0 L	0.8 L	14	
		Endosulfan 50W	1.75 kg	0.7 kg	14	
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	
spinosad	naturalyte	Success 480 SC	182 mL	72.8 mL	1	Maximum 3 applications/yr.
Cutworms[2]						
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.48–0.96 L	70	24-hr re-entry period. Use high rate on large larvae or dry soils.
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.96 L	70	24-hr re-entry period. Use high rate on large larvae or dry soils.
Leaf Miners						
cyromazine	triazine	Citation 75WP	188 g	75.2 g	7	12-hr re-entry period. Apply when adult leaf miners first appear.

[1] DHI = Days to Harvest Interval.
[2] Seedling treatments.

Period of Activity: Optimal temperatures range from 21°C–32°C (70°F–90°F). Egg-laying is reduced at temperatures below 10°C (50°F). The PLM is typically a late-season pest with populations peaking at the end of August through the beginning of September.

Thresholds: None established.

Management Notes: Harvesting susceptible crops before the beginning of September may avoid population peaks when the most severe damage occurs. Insecticide applications should be made as soon as PLM adults first appear. Chemical control options are listed in Table 6–17, *Celery Insect Control Recommendations*, above.

CARROT WEEVIL

Carrot weevil can seriously damage celery roots and the crown, causing stunting and plant collapse. For monitoring information, see the section *Carrot Weevil*, on page 77. Chemical control options are listed in Table 6–17, *Celery Insect Control Recommendations*, page 81.

CABBAGE LOOPER

This is a rare problem in Ontario celery, however, it can cause sporadic damage. Five percent infestation is suggested as a threshold. See Table 6–17, *Celery Insect Control Recommendations*, on page 81.

For more information on insect pest management in celery, see the following OMAF Factsheets and publication:

- *The Aster Leafhopper and Aster Yellows*, Order No. 98-057
- *Caterpillar Pests of Crucifer Crops*, Order No. 99-035
- *Leaf Miners Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039
- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*

Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 57.

Storage

Do not store celery that has been badly damaged by frost, disease or handling. A relative humidity of 95%–98% and a temperature of 0°C (32°F) are ideal. Store celery in a room that is free from odours. Plants readily absorb foreign flavours. Field heat should be removed by hydro-cooling or vacuum-cooling, before placing in large storage rooms.

Caution

Some individuals may be sensitive to the natural chemicals found in celery. These substances increase if celery is diseased. Using rubber gloves when handling celery and leg protection when walking in the field will prevent the development of skin rashes.

COLE CROPS
BROCCOLI, BRUSSELS SPROUTS, CABBAGE, CAULIFLOWER, HORSERADISH, KALE, KOHLRABI

Production Requirements

All cole crops are cool-season crops. They grow best in moderate temperatures and can sometimes withstand mild frosts. Cauliflower is the most sensitive to adverse weather. Cole crops have a relatively high moisture requirement. Even moderate drought stress at any time during the growing season may cause significant reductions in growth, yield or quality. Growth during dry periods may cause tipburn, bolting and/or buttoning.

Broccoli, Brussels sprouts, cabbage and cauliflower mature in 70–120 days. Most kale and kohlrabi mature in 50–55 days.

Average Yields

Crop	per acre	per hectare
Broccoli	260–320 cases (12, 14 or 18 bunches/case)	650–800 cases
Brussels sprouts	10,000 –12,000 lb	11,000–13,500 kg
Cabbage	650–1,000 cases (12 or 16 heads/case)	1,500–2,500 cases
Cauliflower	450–700 cases (6, 9, 12 or 16 heads/case)	1,000–2,000 cases
Horseradish	6,750–10,800 lb	7,500–12,000 kg
Kale	40,000 lb	45,000 kg
Kohlrabi	12,000–16,000 lb	13,500–18,000 kg

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under Ontario growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding, Spacing and Establishment

Cole crop seeds will germinate at temperatures as low as 4°C (39°F). However, they develop best at temperatures ranging from 21°C–24°C (70°F–75°F). Direct seeding in the field is possible for late summer and fall crops of cabbage, cauliflower, broccoli and Brussels sprouts. However, this practice is not widely used in Ontario. Consider establishing transplants from plug trays as a method of promoting uniform size and maturity.

Despite the higher initial cost of plug plants, the benefits include better seed use efficiency and reduced transplanting and thinning costs. Plug-raised plants also establish quickly and provide a more uniform and vigorous stand compared to bare-root transplants.

Table 6–18.
Cole Crop Spacing and Seeding Rates

Crop	Row Spacing cm (in.)[1]	In-Row Spacing cm (in.)	Seed Required g/ha (g/ac)
Early cabbage and broccoli[2]	60–75 (24–30)	30–45 (12–18)	300–350 (120–140)
Late cabbage, cauliflower and Brussels sprouts[3]	75–90 (30–35)	45–60 (18–24)	300–350 (120–140)
Horseradish	75–90 (30–35)	40–60 (16–24)	300–350 (120–140)
Kale	70–80 (28–32)	thinned to about 30 (12) apart	300–350 (120–140)[4]
Kohlrabi	70–80 (28–32)	thinned to about 10 (4) apart	300–350 (120–140)[4]

[1] New, more compact hybrids may be grown at closer spacings than the traditional cultivars.
[2] Increased plant spacings are required for broccoli crops that will be harvested during the hot, humid weather of late August to early September.
[3] Close square spacing of 60 x 60 cm (24 x 24 in.) or even 53 x 53 cm (21 x 21 in.) is required to improve the uniformity of Brussels sprouts that are grown for once-over harvesting and/or where smaller sprouts are required for freezing.
[4] Direct seeded.

See Table 6–18, *Cole Crop Spacing and Seeding Rates*, above.

Fertility

Starter Solution

If no insecticide is being added to the planting water, use a starter solution high in nitrogen such as 20-20-20 at 1 kg /200 L and apply 0.2–0.3 L per plant. Under high temperatures or in dry sandy soils, use half the recommended rate (in the same volume of water). This will reduce the risk of crop injury under these growing conditions.

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Table 6–19.
Cole Crop Nitrogen Recommendations

Soil	Actual N kg/ha (lb/ac)		
	Broccoli, Cauliflower, Brussels Sprouts	Cabbage	Horseradish, Kale, Kohlrabi
Mineral Soils[1]			
Preplant	100 (89)	130 (116)	80 (71)
Side-dress[2]	30 (27)	40 (36)	30 (27)
Total	**130 (116)**	**170 (151)**	**110 (98)**
Muck Soils			
Preplant	70 (62)	100 (89)	70 (62)
1st side-dress	30 (27)	30 (27)	30 (27)
2nd side-dress	30 (27)	30 (27)	30 (27)
Total	**130 (116)**	**160 (142)**	**130 (116)**

[1] If rainfall is excessive, an additional 40 kg of nitrogen/ha may be side-dressed on sandy soils.
[2] 3 weeks after field setting.

Broadcast and incorporate the recommeded preplant nitrogen with all the required potash and potassium. Side-dress the remaining nitrogen approximately 3 weeks after field setting. See Table 6–19, *Cole Crop Nitrogen Recommendations*, above.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

If phosphate and potash are required, they should be broadcast and incorporated prior to planting.

Micronutrients

BORON DEFICIENCY

Boron deficiency has been shown to cause hollow stem in broccoli, but not all hollow stem is caused by boron deficiency. See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

MOLYBDENUM DEFICIENCY

Molybdenum deficiency causes whiptail in cauliflower, broccoli and Brussels sprouts. See the section *Molybdenum*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

See OMAF Publication 701, *Integrated Pest Management for Crucifers in Ontario*, for a comprehensive guide to insect and disease management in cole crops.

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information, see the section *General Insects and Diseases of Vegetable Crops*, on page 54.

Hot-water treatment is most important to help prevent black rot, blackleg and bacterial leaf spot (see the section *Hot-Water Treatment*, on page 179).

To prevent damping-off, seedling blight and seed decay, apply Thiram 75 WP at a rate of 90 g per 25 kg or seed (not for use on kale, horseradish or kohlrabi.)

DOWNY MILDEW

Identification: Symptoms appear as yellow spots on the upper surfaces and greyish-white fungal growths on the underside of leaves. Infected cauliflower curds develop dark-grey spots. When the curds are cut open, a grey streaking is evident beneath the florets. In broccoli, grey streaking occurs beneath the beads. This discolouration leads back to the main stem. Cabbage heads develop numerous black spots.

Development: Infection can occur at any growth stage. Cool temperatures of 10°C–15°C (50°F–59°F) and prolonged periods of leaf wetness, dew or fog are required. This fungus overwinters in seed and on infected plants. Downy mildew fungi survive for at least 1 year in the soil and 2 years in infected seed.

Thresholds: None established.

Management Notes: Plant into well-drained soil conditions. Avoid excessive use of overhead irrigation. Practice a 2-year rotation with non-crucifers. Resistant broccoli varieties are available.

If weather conditions favour disease development, apply one of the preventative fungicides listed in Table 6–20, *Cole Crop Disease Control Recommendations*, on page 85.

FUSARIUM WILT (CABBAGE YELLOWS)

Identification: Infected seedlings will turn yellow and die within 2–4 weeks. The lower leaves are affected first. The yellowing is often more intense on one side of the plant.

Table 6–20.
Cole Crop Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Downy Mildew, Black Leaf Spot						
zineb	dithiocarbamate	Zineb 80 W	2.25–3.25 kg	0.9–1.3 kg	7	Not on horseradish, kale or kohlrabi.
copper sulphate[2]	inorganic	Copper 53 W[2]	4.0 kg	1.6 kg	1	Not on horseradish, kale or kohlrabi.
chlorothalonil	chloronitrile	Bravo 500	2.5–4.8 L	1–1.9 L	7	Not on horseradish, kale or kohlrabi.
fosetyl-al	phosphonate	Aliette 80 WDG	2.25–3.12 kg	0.9–1.25 kg	7	Broccoli only. Max 5 applications/yr. 12-hr re-entry period.
Black Leaf Spot Only						
iprodione[3]	dicarboximide	Rovral [3]	3 kg	1.2 kg	7	Storage cabbage.
					5	Cauliflower.
Clubroot (transplant treatment)[4]						
quintozene	chlorophenyl	Quintozene 75 WP	250 g per 100 L water Minimum 200 mL per plant.			Provide good agitation during application.
Alternaria and Cercospera						
pyraclostrobin	strobilurin	Cabrio EG	0.56–1.1 kg	224–440 g	3	**Horseradish only.** Maximum 3 applications. Apply no more than 2 sequential applications.

[1] Days to Harvest Interval.
[2] Fixed copper may be phytotoxic to cauliflower.
[3] Apply Rovral on storage cabbage 7–14 days prior to harvest and on cauliflower 1–2 days prior to tying.
[4] Chemical control of clubroot is inconsistent.

Development: Fusarium wilt is soil borne. Plants may be affected at any time during growth. It enters the plant through young rootlets or through wounds in older roots. Yellows is a warm-weather disease and will not develop below 16°C (61°F) or above 32°C (90°F).

Management Notes: Use certified, disease-free seed and resistant cultivars (if available). Potassium deficiency may further aggravate this disease.

CLUBROOT

Identification: The first noticeable symptom of clubroot is the wilting, stunting and yellowing of plants in patches in the field. When the plants are pulled, a characteristic "clubbing" of the root tissue is evident. Severely distorted roots have difficulty absorbing water and minerals from the soil.

Development: Clubroot is a soil-borne disease. It affects all members of the crucifer family. Clubroot is present in the soil in most areas of the province. Once in a field, the resting spores persist for many years.

Management Notes: Control cruciferous weeds and rotate with non-crucifer crops. Maintain a soil pH of 7.2. The clubroot fungus spores need free water to move in the soil. Plant into well-drained soils. Muck soils are at a high risk of clubroot infection. Grow only short-season (less than 6 weeks) crucifer crops on high-risk soils.

BLACK ROT

Identification: V–shaped, yellow lesions develop along the leaf margins. As the lesions expand, the tissue turns brown, and the small veins become blackened.

Development: Black rot is spread rapidly during warm, humid weather. Once in the soil, the bacteria spread by splashing rain and wind. Bacteria enter plants through wounds or natural openings at the leaf margins called "hydathodes."

Management Notes: Use certified, disease-free seed and/or hot-water-treated seed. Discard all diseased or unhealthy transplants before planting. Follow a 2–3-year crop rotation to non-crucifers and control all cruciferous weeds.

ALTERNARIA BLACK SPOT

Identification: Small, yellowish lesions develop on older leaves. As the spots expand, they resemble a "target" with concentric light and dark areas. On cauliflower and broccoli, black, sunken spots develop on individual florets. Infections on cabbage heads range in size from pinpoint to several centimetres in width.

Development: Alternaria black spot is seed-borne. It also survives on many cruciferous weeds. It is spread by wind throughout the summer season. Cool, humid conditions favour black spot development.

Thresholds: None established.

Management Notes: Adequate air circulation will reduce humid conditions in the canopy. Ensure that cabbage heads are free of alternaria black spot before going into storage. If this disease is present in the field, protect the plants with a fungicide prior to harvest. See Table 6–20, *Cole Crop Disease Control Recommendations*, on page 85.

BACTERIAL SOFT ROT

Identification: Infected leaf or head tissue often takes on a tan colour, becoming moist and mushy and developing a foul odour.

Development: Soft rot spreads rapidly in warm, humid conditions. Insect damage may predispose plants to soft-rot infection.

Management Notes: Plant into well-drained soils and maximize air flow through the plant canopy. Avoid overhead irrigation once the disease has been diagnosed in a field. Rotate with less-susceptible crops (cereals or corn) and control chewing insects. In storage, temperatures below 4°C (39°F) inhibit the development of new infections. Practice good storage sanitation (see the section *Storage Sanitation*, on page 49).

BROWN HEART OR HOLLOW STEM

Some, although not all, hollow stem in broccoli is caused by boron deficiency. See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

WHIPTAIL

Whiptail in cauliflower, broccoli and Brussels sprouts is caused by molybdenum deficiency. See the section *Molybdenum*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

For further information on cole crop diseases, consult the following OMAF Factsheets:

- *Fungal Diseases of Cruciferous Crops*, Order No. 85-043
- *Bacterial Diseases of Cruciferous Crops*, Order No. 86-046

Insects

APHIDS, CUTWORMS, SLUGS, TARNISHED PLANT BUG

For identification and management information on these common vegetable insects affecting cole crops, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. See also Table 6–22, *Cole Crop Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations*, on page 88, and Table 6–24, *Cole Crop Aphid and Swede Midge Control Recommendations*, on page 91.

CABBAGE MAGGOT

Identification: The cabbage maggot adult is a grey fly, approximately half the size of the common housefly. The female lays eggs in cracks in the soil at the base or near seedlings. The small (1-mm) white eggs look like tiny grains of rice. The larvae are small (7 mm or ¼ in.), legless and white. The maggots tunnel along the roots of crucifers. These wounds act as points of entry for soft rot bacteria.

Period of Activity: There are three periods of egg-laying throughout the season. The first generation is the most active and most damaging. It occurs from mid-May through June (flowering of yellow rocket). A second occurs in mid-July (flowering of day lilies) and a third in late August (flowering of goldenrod). These dates are only approximate and activity varies depending on regional temperatures and differences in soil type.

Thresholds: Cabbage root maggot management is primarily preventative.

Management Notes: See Table 6–21, *Cole Crop Root Maggot Control Recommendations*, on page 87. Later plantings are less likely to require protection.

FLEA BEETLES

Identification: This beetle is small (2–3 mm) and shiny black in colour. Adults are active and jump when disturbed. Feeding damage consists of numerous "shot-holes," 1–5 mm in diameter. At the seedling stage, flea beetle feeding can kill the plant.

Period of Activity: Adult flea beetles overwinter in leaf litter and emerge early in the spring (mid-May.) Eggs are deposited near the roots of host plants throughout the spring and early summer. Larvae develop on the roots. In late July, adults emerge from the soil, feed and then seek hibernation sites in the fall.

Thresholds: Up to the 6-leaf stage, plants can tolerate no more than 1 flea beetle per plant. After this stage, feeding will not interfere with plant growth.

Table 6–21.
Cole Crop Root Maggot Control Recommendations

Common Name	Group	Trade Name	Rate	DHI[1]	Notes
Planting-Water Treatment					
azinphos-methyl	organophosphate	APM 50 W	1 kg in 1,000 L of water Apply 115–170 mL/plant in transplant water.	21	For cabbage, cauliflower, broccoli, Brussels sprouts only. Repeat in 2–3 wk. 48-hr re-entry period. Do not use liquid formulations of azinphos-methyl as a transplant drench (phytotoxicity will occur).
		Guthion Solupak			
		Sniper 50W	1 kg in 1,000 L of water Apply 115–170 mL/plant in transplant water.		
chlorpyrifos	organophosphate	Lorsban 50 W	65 g/200 L of water Apply 200 mL/plant.	32	For cabbage only. Do not use with starter fertilizers.
		Pyrifos 50 W			
Treatment After Planting					
azinphos-methyl	organophosphate	APM 50 W	1 kg in 1,000 L of water Apply 115–170 mL/plant.	21	For cabbage, cauliflower, broccoli, Brussels sprouts only. 48-hr re-entry period. Do not use liquid formulations of azinphos-methyl as a transplant drench (phytotoxicity will occur).
		Guthion Solupak 50 WP			
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/130 L of water per 1,000-m row	32	For cabbage, cauliflower, broccoli, Brussels sprouts only. Apply in a 10-cm (4-in.) band on each side of the plant 3 days after transplanting. Maximum 2 applications/yr (3 on Brussels sprouts).
		Pyrinex 480 EC			
Direct-Seeded Crops					
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/1,000-m row	32	For cabbage, cauliflower, broccoli only. Apply 10 cm (4 in.) on each side of the plant 7–10 days after seeding.
		Pyrinex 480 EC			
		Lorsban 15 G	0.6–1.0 kg/1,000-m row		For cabbage, cauliflower, broccoli, Brussels sprouts only.
		Pyrifos 15 G			

[1] Days to Harvest Interval.

Caution

- Do not use emulsifiable formulations in the planting water.
- Do not add fertilizer to planting water containing an insecticide unless recommended by the manufacturer or until experience has proven the mixture to be safe.

Management Notes: Transplants are less susceptible to damage than direct-seeded crops. Flea beetles can spread black rot disease. Beetles tend to prefer the Asian crucifers over traditional cole crops. Trap crops, such as Indian mustard, have worked in traditional crucifers. Early plantings may be protected with row covers.

See Table 6–22, *Cole Crop Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations*, on page 88.

THRIPS

Identification: Thrips are small (< 3mm), soft-bodied insects. They are cream-to-light-brown in colour. Thrips have sucking-rasping mouth parts and cause tissue damage when they feed on the leaves. The plant responds by forming scar tissue at the feeding site, giving the leaf a rough, rusty, warty appearance. Thrips damage can occur on all cole crops. However, cabbage appears to be the most susceptible.

Period of Activity: Thrips overwinter on grasses (especially winter wheat) and alfalfa. They can also be found in abundance along roadside ditches. They migrate into cole crop fields as the weedy roadsides dry down and the winter wheat and alfalfa are harvested.

Thresholds: None established. If field monitoring indicates a need, start spraying for thrips once cupping of cabbage occurs.

Management Notes: Cabbage varieties vary in their susceptibility to thrips. Late plantings often suffer less damage than earlier ones. Harvest cabbage at the proper maturity; over-mature cabbage is a prime target for thrips.

See Table 6–22, *Cole Crop Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations*, on page 88.

Table 6–22.
Cole Crop
Flea Beetles, Thrips, Cutworms and Slugs Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Flea Beetles						
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.0 L	0.6–0.8 L	7	Maximum 3 applications per year. Not on horseradish, kale, kohlrabi.
		Endosulfan 50W	1–1.75 kg	0.4–0.7 kg	7	
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1 L	3	For cabbage and cauliflower.
					5	For broccoli, kohlrabi and Brussels sprouts.
					7	For horseradish.
					21	For kale.
cypermethrin[2]	pyrethroid	Ripcord 400 EC[2]	87.5–125 mL	35–50 mL	3	Not on horseradish, kale, kohlrabi. Maximum 3 applications/yr.
deltamethrin	pyrethroid	Decis 5 EC	150–200 mL	60–80 mL	3	Use on cabbage only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	42 mL	17 mL	1	For cabbage. 24-hr re-entry period. Maximum 3 applications/yr.
					3	For broccoli, cauliflower, Brussels sprouts. 24-hr re-entry period. Maximum 3 applications/yr.
permethrin	pyrethroid	Pounce	90–180 mL	36–72 mL	2	For horseradish.
					3	For cabbage, cauliflower, Brussels sprouts.
					7	For broccoli.
Thrips						
cypermethrin[2]	pyrethroid	Ripcord 400 EC[2]	87.5–125 mL	35–50 mL	3	For cabbage, cauliflower, broccoli, Brussels sprouts only.
		Cymbush 250 EC[2]	200 mL	80 mL	3	For cabbage, cauliflower, broccoli, Brussels sprouts only. Use Agral 90 at 300 mL/1,000 L spray.
Cutworms						
permethrin	pyrethroid	Pounce	180–390 mL	72–155 mL	3	Brussels sprouts, cabbage, cauliflower. Use high rate on dry soils or large larvae.
					7	Broccoli. Use high rate on dry soils or large larvae.
cypermethrin[2]	pyrethroid	Ripcord 400 EC[2]	175 mL	70 mL	14	Do not disturb soil for 5 days after application.
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.5–1 L	32	For cabbage, cauliflower, broccoli, Brussels sprout only. Apply at 2–5-leaf stage.
		Pyrinex 480 EC	1.2–2.4 L	0.5–1 L	32	For cabbage, cauliflower, broccoli, Brussels sprout only. Apply at 2–5-leaf stage.
Slugs						
ferric phosphate	inorganic	Sluggo	25–50 kg	10–20 kg	0	Use high rates on heavy infestations.
methomyl	carbamate	Lannate	775 g	310 g	30	For Brussels sprouts only. 24-hr re-entry period.

[1] Days to Harvest Interval.
[2] Do not use on muck soils.

IMPORTED CABBAGEWORM, CABBAGE LOOPER, DIAMONDBACK MOTH CATERPILLAR

Identification: Imported cabbageworm (ICW) caterpillars are leafy green and velvety in appearance. They have a pale yellow stripe down the centre of their back. The cabbage looper (CL) caterpillar is similar in size, smooth and pale green, with a thin white line along each side and two faint lines down the middle of the back. Both the ICW and the CL chew large ragged holes in the leaves.

The diamondback moth larvae are much smaller than the other two species. When disturbed, they wiggle frantically and rapidly, attach a silken thread to the leaf and dangle over the edge. Diamondback moth larvae chew through the

inner-leaf layers, leaving the waxy epidermis, creating a "window-pane."

Period of Activity: Infestations of the ICW and DBM begin very early in the season. There is a possibility that diamondback moth is overwintering in some areas along Lake Ontario and Lake Erie. CL do not usually appear until mid-July. However, they have been found earlier in the southwestern municipalities of Chatham-Kent and Essex.

Thresholds: Using the Cabbage Looper Equivalent method (CLE), thresholds are 0.3 for cabbage and 0.2–0.3 for cauliflower and broccoli.

Using the Percentage Infestation Method, thresholds are:

Cabbage	20%–30% before head fill 10%–15% after
Cauliflower & broccoli	20%–30% before heading 5%–10% after

For more information on the calculation of these thresholds, see OMAF Publication 701, *Integrated Pest Management for Crucifers in Ontario.*

Management Notes: Insecticides are less effective against large larvae. Begin application of insecticides when young larvae are found and continue on a 5–10-day schedule, or as necessary for adequate protection of the crop. Scouting is an excellent way to assess the population of cole-crop caterpillars.

See Table 6–23, *Cole Crop Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations*, on page 90. Diamondback moth develops resistance very quickly. To limit the development of resistance, always alternate between chemical families. Use pyrethroid insecticides during the fall, as they are more effective under cool conditions.

Note: The carbamates and the pyrethroids have been inconsistent in some areas. Spray small areas first to check if the product is working in your area.

SWEDE MIDGE

Identification: The swede midge is a new quarantined pest in Ontario and Quebec. Swede midge damage can occur on all cole crops. Clusters of eggs are laid on the youngest plant tissue. The translucent-to-creamy-yellow-white larvae are 3 mm in length when mature.

Damaged seedlings often appear twisted and have a noticeable brown scar or a gall at the growing point. If damage occurs before the plant reaches the button stage, the plant will be barren. Later feeding injury results in twisted and distorted heads. Also look for brown, corky scarring along the leaf petiole.

Period of Activity: First generation swede midge adults emerge from overwintering pupae from mid-May to the beginning of June. It appears that there are three to four overlapping populations of swede midge in Ontario. Research into the biology of the swede midge in Ontario is still ongoing.

Thresholds: None established.

Management Notes: The swede midge is very difficult to manage. Since the adults are weak fliers, primary introduction occurs through the movement of transplants. Greenhouse transplant growers in quarantined areas must follow the Canadian Food Inspection Agency (CFIA) Swede Midge Certification Protocol (SMCP) to ensure swede midge–free plants to their buyers.

Chop and bury infested residue. Most pupae are found within the top 5 cm of the soil. Deep plowing will reduce the number of viable pupae. Pupae may remain dormant for two years, making a 2–3-year rotation away from crucifer crops essential.

Foliar insecticides are used with some success to kill adults. Systemic insecticides are required to kill the larvae. See Table 6–24, *Cole Crop Aphid and Swede Midge Control Recommendations*, on page 91.

For more cole crop insect information, consult the following OMAF Factsheets:

- *Caterpillar Pests of Cruciferous Crops*, Order No. 99-035
- *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025
- *Thrips on Onions and Cabbage*, Order No. 99-027
- *The Swede Midge — A new pest in crucifer crops in Ontario*, Order No. 03-035

Nematode Control

See the section *Nematodes*, on page 57, for nematode control recommendations.

Table 6–23.
Cole Crop
Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Bacillus thuringiensis	microbial	Dipel 2XDF	55–550 g	22–220 g	0	275–550 g for loopers.
		Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	Use higher rates for looper control, heavy infestations or when foliage is dense.
		Bioprotec CAF	1.4–2.8 L	0.5–1.1 L	0	
permethrin	pyrethroid	Pounce	90–180 mL	36–72 mL	3	Cabbage, cauliflower, Brussels sprouts.
					7	Broccoli.
deltamethrin	pyrethroid	Decis 5 EC	150–200 mL	60–80 mL	1	Brussels sprouts only.
					3	Cabbage, cauliflower, broccoli only.
cypermethrin[2]	pyrethroid	Ripcord 400 EC[2]	87.5–125 mL	35–50 mL	3	Cabbage, cauliflower, broccoli, Brussels sprouts only.
		Cymbush 250 EC[2]	140 mL	56 mL	3	Cabbage, cauliflower, broccoli, Brussels sprouts only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	42 mL	17 mL	1	Cabbage. Imported cabbageworm and diamondback moth larvae.
					3	Broccoli, cauliflower, Brussels sprouts. Imported cabbageworm and diamondback moth larvae.
			83 mL	33 mL	1	Cabbage. Cabbage looper.
					3	Broccoli, cauliflower, Brussels sprouts. Cabbage looper.
methomyl[2]	carbamate	Lannate[2]	270–540 g	108–216 g	1	Cabbage. 24-hr re-entry period.
					7	Cauliflower, broccoli, Brussels sprouts.
carbaryl	carbamate	Sevin XLR Plus	2.5–5.25 L	1–2.1 L	3	Cabbage and cauliflower.
					5	Broccoli and Brussels sprouts.
					7	Horseradish.
					21	Kale.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1–1.75 kg	0.4–0.7 kg	7	Not on kale, kohlrabi, horseradish. Use high rate on loopers.
		Thionex EC	1.5–2.0 L	0.6–0.8 L	7	Not on kale, kohlrabi, horseradish. Use high rate on loopers.
naled	organophosphate	Dibrom EC	1.1–2.2 L	0.4–0.9 L	4	2.2 L rate for loopers only. Not on kohlrabi, horseradish.
methamidophos[3]	organophosphate	Monitor 480[3]	1.1–2.25 L	0.4–0.9 L	7	For cabbage, cauliflower.
					14	Broccoli, Brussels sprouts. Use high rate on cabbage loopers.
azinphos-methyl[3]	organophosphate	Guthion Solupak[3]	1.12–1.75 kg	0.4–0.7 kg	7	Brussels sprouts. Maximum 3 applications/yr.
					15	Broccoli, cauliflower. Maximum 3 applications/yr.
					21	Cabbage. Maximum 3 applications/yr.
		APM 50 W[3]	1.1–1.75 kg	0.4–0.7 kg	7	Brussels sprouts. Maximum 3 applications/yr.
					15	Broccoli, cauliflower. Maximum 3 applications/yr.
					21	Cabbage. Maximum 3 applications/yr.
		Sniper 50W[3]	1.1–1.75 kg	0.4–0.7 kg	7	Brussels sprouts. Maximum 3 applications/yr.
					15	Broccoli, cauliflower. Maximum 3 applications/yr.
					21	Cabbage. Maximum 3 applications/yr.
acephate	organophosphate	Orthene 75 SP	*0.75–1.1 kg	0.3–0.4 kg	28	Maximum 4 applications/yr. Not on broccoli, kale, kohlrabi, horseradish.
spinosad	naturalyte	Success 480 EC	182 mL	72.8 mL	3	Mamimum 3 applications/yr.

[1] Days to Harvest Interval.
[2] Do not use on muck soils.
[3] 48-hour re-entry period.

Table 6–24.
Cole Crop Aphid and Swede Midge Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Swede Midge						
cyhalothrin-lambda	pyrethriod	Matador 120 EC	83 mL	33.2 mL	1	Cabbage Maximum 3 applications/yr. Allow 7 days between applications.
					3	Broccoli, Brussels sprouts, cauliflower Maximum 3 applications/yr. Allow 7 days between applications.
Aphids and Swede Midge						
acetamiprid	chloronicotinyl	Assail 70 WP	56–86 g	22.4–34.4 g	7	Use high rate for swede midge Maximum 5 applications/yr. Alternate sprays with other insecticide families.
Aphids						
dimethoate	organophosphate	Cygon 480	0.7–1.0 L	0.28–0.4 L	4	Cabbage, cauliflower, broccoli.
					7	Kale.
					21	Brussels sprouts. Use low rate on Brussels sprouts.
		Lagon 480	0.7–1.0 L	0.28–0.4 L	4	Cabbage, cauliflower, broccoli.
					7	Kale.
					21	Brussels sprouts. Use low rate on Brussels sprouts.
methamidophos	organophosphate	Monitor 480	1.1–2.25 L	0.4–0.9 L	7	Cabbage, cauliflower. 48-hr re-entry period.
					14	Broccoli, Brussels sprouts. 48-hr re-entry period.
naled	organophosphate	Dibrom	1.1 L	0.4 L	4	Not on kohlrabi, horseradish.
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.4 kg	28	Not on broccoli, kale, kohlrabi, horseradish. Maximum of 4 applications/yr.
imidacloprid	cholornicotinyl	Admire 240 F	730 mL	292 mL		**Side-Dress Application – Brussels Sprouts only** Inject to a depth of 2.5 cm, 5–10 cm to the side of each row. Maximum 1 application/yr.
			200 mL	80 mL		**Foliar Application – Brussels Sprouts only** Do not make a foliar application following a soil application. Maximum 2 applications/yr.

[1] Days to Harvest Interval.

Physiological Disorders

Cabbage Splitting

Well-developed cabbage heads may split or burst if rain or a heavy irrigation follows a dry spell. Splitting results from rapid new growth due to the increased moisture. Maintain steady plant growth with timely irrigation. Deep cultivation may also break up roots, preventing excessive growth.

Bolting

Low temperatures early in the growing season may cause premature seedstalk development. The earlier the seed is sown, the greater the bolting tendency. Bolting may also be caused by extreme changes in temperature, poor soil conditions or low nutrient levels. Some cultivars are more susceptible to bolting.

Tipburn of Cauliflower and Cabbage

Tipburn can occasionally cause severe economic losses in cabbage and cauliflower. Tipburn is a breakdown of plant tissue near the centre of the head in cabbage and on the inner wrapper leaves of cauliflower. It is a physiological disorder associated with an inadequate supply of calcium in the affected leaf margins causing a collapse of the tissue and death of the cells.

High temperatures and fluctuating soil moisture conditions hinder the movement of calcium into the leaves, leading to tipburn.

Secondary rot organisms such as *Erwinia* sp. can follow tipburn. Many varieties of cabbage and cauliflower have been noted to be resistant to tipburn problems. See the section *Calcium*, on page 20, and Table 2–8, *Application*

Rates for Magnesium, Calcium and Micronutrients, on page 21.

Cauliflower Buttoning

Buttoning is the premature formation of a cauliflower curd. Buttoning usually occurs shortly after planting in the field. The curd forms very early in the plant's life, and the leaves are not large enough to nourish the curd to a marketable size.

Losses are usually most severe in the early-planted crop during cold, wet seasons. Conditions that reduce the vigour of the plant and retard vegetative growth appear to encourage buttoning. Some cultivars are more susceptible to buttoning. Conditions that may cause buttoning include:

- too-rapid hardening-off treatment of young plants raised under protection
- insufficient hardening-off treatment of young plants before being planted in the field
- unbalanced soil fertility in the field (particularly low nitrogen)
- low soil moisture
- cold weather, 4°C–10°C (39°F–50°F) for 10 days or more, especially in combination with excess moisture
- certain diseases, insects and trace-element deficiencies, such as clubroot, root maggot and molybdenum deficiency (whiptail)

Harvest

Broccoli

Cut heads when the clusters are green and compact. Open, yellow clusters are undesirable. Terminal broccoli heads are cut with 15–20 cm (6–8 in.) of stem. Lateral shoots from the axils of the leaves develop into marketable heads soon after the terminal head is removed. These laterals produce a continuous crop for several weeks. Some of the new hybrids produce very few laterals. Continuity of production with these cultivars may be obtained by successive plantings in the spring and summer.

Brussels Sprouts

Harvesting should begin when the sprouts are firm and well formed. When hand picking, break off the leaf below the sprout and remove the sprout. The upper sprouts continue to form and enlarge as the lower ones are harvested. Pick early sprouts as soon as they mature. Otherwise, they will open up, become soft, turn yellow and rot.

For once-over harvest, topping the plants will prevent any further extension of growth and encourage the maturity of the small sprouts at the top of the stem. Topping is normally done when the sprouts at the bottom of the stem are about 12–20 mm (½–¾ in.) in diameter. A full stem of uniform, marketable-sized sprouts will develop about 4 weeks later. Do not de-leaf plants more than 1 day before harvest.

Cabbage

Harvest cabbage before the top cover-leaves begin to lose their colour. For best storage results, pick cabbage at a slightly immature stage. Immature heads will retain their colour for a longer period of time.

Cauliflower

A perfect head of cauliflower is essentially pure white or pale cream. Heads exposed to sunlight develop an objectionable yellow pigment. To exclude sunlight, tie the outer leaves over the heads when the heads are 8–10 cm (3–4 in.) in diameter.

In hot weather, blanching may take only 3–4 days. In cool weather, when growth is slow, 8–12 days or more may be required. Mark heads tied at different times with different colours of twine or rubber bands to indicate probable maturity date. Some cultivars are better able than others to give natural curd protection by the inner wrapper leaves, without tying.

Storage

Prevent the development of rots and disease in storage by removing field heat from the crop as soon as possible. All cole crops should be stored at 0°C (32°F) and 95%–100% relative humidity. See Table 4–13, *Storage Life for Fresh Vegetables in Commercial Storage*, on page 48.

CUCURBITS
CUCUMBER, MUSKMELON, WATERMELON, PUMPKIN, SQUASH (ALSO KNOWN AS VINE CROPS)

Production Requirements

Cucurbits are warm-season vegetables. They do not tolerate frost. Temperatures below 10°C (50°F) may impact crop growth and negatively affect fruit quality. The vine crops require well-drained, compaction-free locations with ample fertility. Melons, in particular, respond well to plasticulture and fertigation. High levels of soil nitrogen may result in excess leaf growth and poor fruit development. Most vine crops benefit from supplemental bee hives to promote pollination.

Average Time From Flower Set to Harvest

Cucumber (pickling)	4–5 days
Cucumber (slicing)	15–18 days
Muskmelon	40 days
Pumpkin	60–70 days
Summer squash	3–8 days
Winter squash	60–70 days
Watermelon	40 days

Average Yields

Crop	per acre	per hectare
Cucumbers (processing – machine harvest)	4 tons	9 tonnes
Cucumbers (processing – hand harvest)	8–12 tons	8–27 tonnes
Cucumbers (slicing)	200–400 bu	500–1,000 bu
Muskmelons	25 bins	60 bins
Pumpkins	50 bins	125 bins
Winter squash	15–20 bins	40–50 bins
Zucchinni	700 ½-bushel boxes	1,600 ½-bushel boxes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Processing cucumber hybrids have a predominately female flowering habit. However, not all gynoecious hybrids produce 100% female flowers. Ontario day-lengths and temperatures may be responsible for the presence of male flowers on these hybrids. All gynoecious hybrid seed contains 10%–15% standard (monoecious) cultivar, added as a pollinator. For satisfactory fruit set, 10%–20% of the plants should contain a large number of male flowers.

In other vine crops, the normal ratio of male to female flowers is often 10 male : 1 female. This ratio can occasionally reach 100:1.

Seeding and Spacing

Total cucurbit yields tend to increase with plant density. Processing cucumbers for machine harvest benefit the most from close spacings. In other vine crops, high plant populations may result in harvest problems due to excessive vine growth. An overly dense canopy is also more conducive to disease pressure.

In pumpkins and squash, fruit size tends to decrease as plant density increases. Larger sized pumpkin and winter squash varieties will benefit from wider spacing. However, extremely wide rows are slow to close canopy, resulting in higher levels of weed pressure.

Plant seeds into moisture, no more than 2–2.5 cm (1 in.) deep. Deeply planted seed is often slow to emerge, resulting in lower plant populations. Quick, uniform emergence is essential to avoid uneven stands weakened by insects and disease. Delay planting until the soil temperature is 15°C (59°F) or higher. The optimum soil temperature range at planting is 25°C–30°C (77°F–86°F.)

Pickling cucumbers are usually field-seeded from late May to early June for the hand-pick crop. Seeding for once-over mechanical harvesting can be done until mid-July, depending on processor specifications.

Pumpkins and squash for the Hallowe'en market are usually seeded from late May to early June. Plant melon transplants after the risk of spring frost has passed (see Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 37).

See Table 6–25, *Cucurbit Crop Spacing*, on page 94.

For information on producing vine crop transplants, see the section *Vegetable Transplants*, on page 175.

Seedless Watermelon Production

Triploid watermelons will not set fruit unless pollinated by a normal (diploid) watermelon variety. Use one pollinator plant for every 2 seedless ones. For the best results,

Table 6–25.
Cucurbit Crop Spacing

Crop	Row Spacing		In-Row Spacing		Seeding Rate	
	Metric	Imp.	Metric	Imp.	per hectare	per acre
Cucumbers						
Fresh	1.2–1.8 m	4–6 ft	30 cm	12 in.	0.5–1 kg	1.5–2 lb
Cucumbers (processing)						
Handpick	1.1–1.2 m	3.5–4 ft	10–15 cm	4–6 in.	0.5–1 kg	1.5–2 lb
Machine harvest	50–75 cm	20–30 in.	10 cm	4 in.	2–3 kg	5–7 lb
Pumpkins & Squash[1]						
Standard types	1.5–3 m	5–10 ft	60–150 cm	2–5 ft	1–2 kg	2–4 lb
Semi-bush types	1.2–1.5 m	4–6 ft	45–90 cm	1.5–3 ft	1.3–2 kg	3–4 lb
Small bush types	0.9–1.2 m	3–6 ft	45–90 cm	1.5–3 ft	2–3 kg	4–6 lb
Melons[2]						
Muskmelons	1.5–1.8 m	5–6 ft	60–90 cm	2–3 ft	n/a[2]	n/a[2]
Watermelons	1.8–2.5 m	6–8 ft	90–120 cm	3–4 ft	n/a[2]	n/a[2]

[1] Varieties with large fruit size (over 30 lb) will benefit from wider rows and plant spacings. Gourds and mini pumpkins respond to significantly higher plant populations (up to 6,000 plants/ac).
[2] Approximately 2.2 kg of seed are required to produce enough melon seedlings for 1 ha.

mix the pollinator varieties in the same row as the triploids. Plant a pollinator with a different fruit type to distinguish it from the seedless variety at time of harvest. Under cool or stressful growing conditions, some seed development may occur in seedless watermelons.

Pollination

All the vine crops depend on insects to transfer pollen from the male to the female blossoms. Each female blossom must be visited 15–20 times for adequate pollination to occur. Poorly pollinated fruit will usually exhibit awkward shape and poor size. Hollow heart of watermelons may be linked to poor pollination.

In small plantings, there may be enough native pollinating insects to perform this function. In large plantings, the grower is advised to introduce one colony of honeybees for every hectare (2.5 acres). Aim to have the hives in the field at first bloom.

Insecticides will poison bees. Spray only in the evening or at night, after bees have finished foraging for the day. If possible, remove hives from the field prior to spraying. See the section *Prevent Bee Poisoning*, on page 8.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Apply up to 110 kg N/ha (98 lb N/ac). Broadcast 65 kg N/ha (58 lb/ac) and all the phosphate and potash required prior to planting. The remainder of the nitrogen should be side-dressed before the vines start to run. On sandy soils, a second application may be necessary after the vines begin to run, especially following heavy rains.

Alternatively, up to 100 kg (90 lb) of N + K_2O/ha can be applied in a band, 5 cm to the side and 5 cm below the seed at planting. The remainder of the fertilizer requirements should be broadcast before planting.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

If phosphate and potash are required, apply prior to planting.

Fertigation

For fertigated vine crops, broadcast all the phosphate requirement and approximately 30%–50% of the nitrogen and potash requirements prior to planting. The

Table 6–26.
Cucurbit
Nitrogen and Potash Injection Schedules

Stage	Rate per week
Transplanting to fruitset	5 kg/ha (4.5 lb/ac)
Fruit sizing to harvest	10 kg/ha (9 lb/ac)
During harvest	5 kg/ha (4.5 lb/ac)

remainder should be injected through the drip irrigation system at the rates shown in Table 6–26, *Cucurbit Nitrogen and Potash Injection Schedules*, above.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

Seed treated with thiram (dithiocarbamate group) will help prevent damping-off, seedling blight and seed decay. Use 50 g of Thiram 75 WP for every 25 kg of seed. Use sterile soil or soil-less mix for growing seedlings. See the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54, for more information.

POWDERY MILDEW

Identification: Initial symptoms develop on the undersides of older, shaded leaves. The white, powdery growth will spread to the upper leaf surface and down the petiole. Infected leaves wither and die prematurely, impacting both yield and fruit quality.

Development: This disease does not overwinter in Ontario. Spores usually arrive (from the southern United States and Mexico) in mid-summer. Peak infection periods occur when temperatures are in the range of 20°C–26°C (68°F–80°F.) Disease development slows when temperatures climb above 26°C (80°F).

Infections can develop at relatively low humidity (<20%) levels, although humid weather conditions and heavy dews lead to more rapid disease development.

Thresholds: Begin applying protectant fungicides at the first sign of disease. Late July through August is usually the most criticial powdery mildew control period.

Management Notes: There is a wide selection of powdery mildew–resistant varieties available for all types of vine crops. Good spray coverage on both the upper and lower leaf surfaces is important.

BACTERIAL WILT

Identification: Infected leaves develop dull green patches. As the vasular system becomes blocked with bacterium, the runners (and eventually the whole plant) becomes wilted. Plants ultimately turn yellow and die.

Development: This disease overwinters in the stomachs of adult cucumber beetles. Beetles inject the bacterium into the plant as they feed. Vine crops species and cultivars differ in their susceptibility to bacterial wilt. Generally speaking, cucumbers and melons are very susceptible.

Management Notes: Control cucumber beetle feeding to prevent the spread of this disease. See the section *Cucumber Beetles*, on page 96.

ANGULAR LEAF SPOT

Identification: Small, "water-soaked" lesions develop on infected leaves. These lesions will expand in size until they are confined by the veins, resulting in an angular appearance. Affected areas turn brown, and the centres fall out, leaving small holes in the leaf.

Development: This bacterial disease is seed-borne. Bacteria also survive in infected crop residue. In wet conditions, it spreads rapidly across the field through splashing rainwater or machinery.

Thresholds: None established. Apply copper fungicides at the first sign of infection.

Management Notes: Angular leaf spot is more prevalent in pumpkins and squash. There is good varietal resistance available in cucumbers. Purchase pathogen-free seed, do not save seed from infected fields. A two-year rotation away from cucurbit vine crops will reduce overwintering innoculum. See Table 6–27, *Cucurbit Disease Control Recommendations*, on page 96.

SCAB AND ANTHRACNOSE

Identification: Both diseases cause leaf spotting and (occasionally) leaf distortion. Severely infected leaves become dry, cracked and ragged-looking. Anthracnose-infected fruit develop sunken lesions, varying in colour from red-brown to black. Scab fruit infection occurs as large, sunken craters with corky margins. Both diseases may develop on fruit in storage.

Development: Scab development favours cool, dry days interspersed with moisture and/or heavy dews. Field infection occurs at temperatures from 17°C–20°C (63°F–68°F.) Melons may develop symptoms in storage

Table 6–27.
Cucurbit Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Angular Leaf Spot						
copper sulphate/ copper hydroxide	inorganic	Copper 53 W	2.5–3.0 kg	1–1.2 kg	1	
		Parasol WP	2.25–3.25 kg	0.9–1.3 kg	1	Cucumbers only.
		Copper Spray	4.0 kg	1.6 kg	1	
Scab and Anthracnose						
chlorothalonil	chloronitrile	Bravo 500	4.8 L	1.9 L	1	
mancozeb	dithiocarbamate	Dithane	1.1–3.25 kg	0.44–1.3 kg	14	
		Manzate 200 DF	2.25–3.25 kg	0.9–1.3 kg	14	Cucumbers only.
		Penncozeb 80 WP	1.1–3.25 kg	0.44–1.3 kg	14	
captan	phthalimide	Maestro 75 DF	2.5–4.5 kg	1–1.8 kg	2	Cucumber only.
		Supra Captan 80 WDG	2.25–4.25 kg	0.9–1.7 kg	2	Use low rate on young plants.
copper sulfate	inorganic	Copper 53 W	2.5–3 kg	1–1.2 kg	1	Anthracnose only.
Powdery Mildew						
chlorothalonil	chloronitrile	Bravo 500	4.8 L	1.9 L	1	
pyraclostrobin	strobilurin	Cabrio EG	560–840 g	224-336 g	3	Maximum 4 applications/yr. **Do not** make more than 1 application before alternating with a different fungicide family.

[1] Days to Harvest Interval.

at temperatures as low as 8°C (46°F). Anthracnose is a late-season disease.

Thresholds: None established. Both diseases are sporadic in Ontario. They may appear during the cooler weather of late summer.

Management Notes: Practice a 2–3-year rotation away from all vine crops. Avoid night-time overhead irrigation during cooler weather. See Table 6–27, *Cucurbit Disease Control Recommendations*, above.

FUSARIUM WILT

Fusarium wilt is a serious problem in muskmelons. Sterilize soil for melon transplants. Grow cultivars resistant to fusarium wilt.

CUCUMBER MOSAIC VIRUS

This virus is transmitted by aphids and cucumber beetles. Transmission occurs very quickly (in less than 1 minute.) As a result, aphid control will not necessarily prevent an infestation. Use of resistant cultivars is the best available means of preventing yield losses.

Control perennial weeds in adjacent fencerows. Milkweed, ground cherry, pokeweed, chickweed and motherwort are alternative hosts to the mosaic virus.

Insects

SEEDCORN MAGGOTS, WIREWORMS, APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting vine crops, see *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–28, *Cucurbit Insect Control Recommendations*, on page 97.

CUCUMBER BEETLES

Identification: Striped cucumber beetles are 6–7 mm (¼ in.) long with 3 black stripes. The less common, spotted cucumber beetle is slightly larger. While feeding damage can seriously harm seedlings, the main threat to vine crop yield is the transmission of bacterial wilt.

Period of Activity: Beetles usually arrive in cucurbit fields as the crop begins to emerge. They may be present in the field through the summer. However, early populations are generally the most damaging. Late-season feeding on the fruit may reduce marketable yields.

Thresholds: Treat when beetles exceed 0.5–1 per plant, as they begin to appear in the field. Use the lower threshold on bacterial wilt–susceptible varieties. A follow-up spray may be necessary, as beetle emergence is often staggered.

Table 6–28.
Cucurbit Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Squash Vine Borer[2]						
Spray						
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg	0.4 kg	2	
		Endosulfan 50 W	1.1 kg	0.44 kg	2	
		Thiodan 4 EC	1.5 L	0.6 L	2	
rotenone	botanical	Rotenone 5	4.5 kg	1.8 kg	1	
Dust						
rotenone	botanical	Rotenone 1% WP	40 kg	16 kg	1	
Cucumber Beetle						
Spray						
azinphos-methyl	organophosphate	Guthion SC	2.25 L	0.9 L	6	**Cucumbers:** 7 days between applications. Maximum 3 applications/yr. 48-hr re-entry period. **Melons and pumpkins:** 5 days between applications. Maximum 2 applications/yr. 48-hr re-entry period.
		Sniper 50 W	1.1 kg	0.45 kg	14	
		Guthion Solupak	1.12 kg	0.45 kg		
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg	0.4 kg	2	
		Endosulfan 50 W	1.1 kg	0.44 kg	2	
		Thiodan 4 EC	1.5 L	0.6 L	2	
methoxychlor	diphenylethane	Methoxychlor 240	3–9 L	1.2–3.6 L	1	Do not use on melons. Will also control leafhoppers.
Dust						
rotenone	botanical	Rotenone 1% WP	40 kg	16 kg	1	
Aphids						
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0 kg	0.4 kg	2	
		Endosulfan 50 W	1.1 kg	0.44 kg	2	
		Thiodan 4 EC	1.5 L	0.6 L	2	
malathion	organophosphate	Malathion 25 W	4.25 kg	1.7 kg	3	Will also control leafhoppers.
			4.0–5.5 kg	1.6–2.2 kg	3	Melons.
		Malathion 500 E	1.8 L	0.72 L	3	Will also control leafhoppers.
			2.25–2.75 L	0.9–1.1 L	3	Melons.
Two-Spotted Spider Mite						
dicofol	diphenylethane	Kelthane 50 W	1.0–1.25 kg	0.4–0.5 kg	7	Maximum 1 application/yr.
Cutworms[3]						
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.48–0.96 L	60	Cucumbers only.
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.96 L	60	Cucumbers only.
carbaryl	carbamate	Sevin XLR plus	2.5 L	1 L	5	Climbing cutworms only.

[1] DHI = Days to Harvest Interval.
[2] Butternut squash is resistant to squash vine borer.
[3] Seedling treatments. Apply at the 2–5 leaf-stage, in 200–400 L of water.

Management Notes: Cucumber beetles tend to congregate in certain areas of the field, making them an excellent candidate for spot spraying. Vine crops vary in their attractiveness to beetles. Zucchini and pumpkins are highly attractive, cucumbers and melons less so. The more attractive species offer opportunities for trap cropping.

See Table 6–28, *Cucurbit Insect Control Recommendations*, above.

TWO-SPOTTED SPIDER MITE

Identification: The adult mite is approximately 0.5–1 mm in length, barely visible to the naked eye. They are a translu-

Bee Warning

Except for rotenone, the insecticides listed in Table 6–28, *Cucurbit Insect Control Recommendations*, on page 97, are toxic to bees. Apply insecticides in the evening when bees are not working in the field. If hives are in the crop, remove them when treating the field.

cent-yellowish colour with two dark spots on the sides of their abdomen. Spider mites feed through sucking mouth parts. Injury first appears as a bronzed, stippled effect. Severe feeding causes curling and drying of the leaves. Symptoms are often confused with drought stress.

Period of Activity: Mite activity is most common in hot, dry conditions. They often move into vine crops (especially watermelons) following wheat harvest.

Thresholds: None established. Melon plants are most susecptible to damage prior to first harvest.

Management Notes: Heavy rain or overhead irrigation often reduces mite levels to tolerable levels. See Table 6–28, *Cucurbit Insect Control Recommendations*, on page 97.

LEAFHOPPERS

High levels of leafhoppers occasionally appear in vine crops after hay is cut in the spring. Feeding damage plugs the vascular system, causing hopper burn. Hopperburn is frequently mistaken for drought stress. See the section *Potato Leafhopper*, on page 67, for more information.

SQUASH BUG

The grey, soft-bodied squash bug is a sporadic pest of pumpkin, squash and zucchini. It prefers sheltered ares, under vines, fruit, etc. The squash bug overwinters as an adult and emerges during mid-summer.

SQUASH VINE BORER

Fleshy, white larvae feed inside the stems and fruit of gourds, pumpkins and squash. This pest is rarely a problem in commercial fields, as borers are generally controlled by cucumber beetle sprays. If feeding occurs, spray the base of plants thoroughly with one of the insecticides recommended in Table 6–28, *Cucurbit Insect Control Recommendations*, on page 97.

Nematode Control

For nematode control recommendations, see the section *Nematodes*, on page 57.

Table 6–29.
Pumpkin and Squash Storage Expectancy

Type	Storage Expectancy
Acorn	4–7 weeks
Pumpkins	8–12 weeks
Butternut	8–12 weeks
Buttercup	10 weeks
Turban	12 weeks
Hubbard	6 months

Curing and Storing Pumpkin and Squash

Curing some types of pumpkin and squash fruit for 10–20 days at 24°C–27°C (75°F–81°F) can decrease the higher water content and improve eating quality. Butternut and hubbard cultivars respond to this treatment, but storage life may be shortened. Curing acorn-type squashes decreases the storage life and eating quality.

- Maintain storage temperatures between 10°C–15°C (50°F–59°F). Vine crops are susceptible to cold injury, which appears after the fruit has been brought back to room temperature.
- Aim for 50%–70% relative humidity. High humidity levels will increase storage rots, while dry conditions will increase weight loss and shrinkage. Weight loss should be kept below 15%.

See Table 6–29, *Pumpkin and Squash Storage Expectancy*, above.

For information on storing cucumbers, melons and summer squash, see Table 4–13, *Storage Life for Fresh Vegetables in Commercial Storage*, on page 48.

The following OMAF Factsheets also pertain to vine crop production:

- *Pollination of Vine Crops*, Order No. 87-043
- *Pumpkin and Squash Production*, Order No. 00-031

EGGPLANT

Production Requirements

Well-drained, sandy loams, with relatively high organic matter levels and a pH of 5.5–6.5, are best for eggplant production. Eggplant require about 55–80 days from transplanting to harvest and 25–40 days from pollination to marketable fruit.

Average Yields

Crop	per acre	per hectare
Eggplant	500 bu graded product	1,250 bu graded product

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Row spacing: 90–120 cm (36–48 in.)

In-row spacing: 45–60 cm (18–24 in.)

Rate: approx. 200–300 g of seed (3–4 oz) will produce enough transplants for 1 ha (ac)

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Apply up to 70 kg N/ha. Broadcast 35 kg N/ha and all of the required phosphate and potash before planting. The remainder of the nitrogen should be side-dressed 3–4 weeks after field setting.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

Starter Solution

At transplanting, apply a high-phosphorous starter solution such as 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or on dry sandy soils, reduce the amount of fertilizer by half but continue to use the same volume of water. This will reduce the risk of crop injury under harsh growing conditions.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

Sow hot-water-treated seed (see the section *Hot-Water Treatment*, on page 179). To prevent damping-off, use sterile soil-less mix and treat seed with thiram (dithiocarbamate group) seed protectant. Use 65–80 g of Thiram 75 WP per 25 kg of seed. See the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54, for more information.

VERTICILLIUM WILT

Identification: V-shaped yellow lesions develop on the older leaves, followed by wilting of the plant and leaf drop. When split length-wise along the stem, infected plants exhibit discolouration of the vascular tissue.

Period of Activity: All season. Symptoms are often more severe after fruit set or during dry periods. Plant-parasitic nematodes may further aggravate this disease.

Thresholds: Soil *Verticillium* and root lesion nematode counts, available from the Pest Diagnostic Lab, University of Guelph, will determine the need for control measures (see Appendix H, *Diagnostic Services*, on page 195.)

Management Notes: Follow a 4–6-year rotation away from all related crops. Cultivars vary in tolerance to verticillium wilt. Soil fumigation may be required if *Verticillium* and nematode counts are high. Nightshade and other solanaceous weeds also harbour this disease. Good weed control throughout the rotation is an important part of wilt control.

PHOMOPSIS BLIGHT

This disease causes circular, brownish spots on leaves and fruit. Black spots (pycnidia) develop in the centres of the lesions. Fruit lesions enlarge to 5–8 cm (2–3 in.) in diameter. Avoid planting in infested fields for 3 years.

Table 6–30.
Eggplant Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Anthracnose, Early Blight, Late Blight						
pyraclostrobin	strobilurin	Cabrio EG	0.56–1 kg	224–400 g	0	**Do not** make more than 2 applications before alternating with a different fungicide family.
boscalid	anilid	Lance WDG	175–315 g	70–126 g	0	**Early Blight Only** **Do not** make more than 2 applications before alternating with a different fungicide family.
Flea Beetles						
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1–2.25 kg	0.4–0.9 kg	2	
		Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50W	1.1–2.25 kg	0.44–0.9 kg	2	
carbaryl	carbamate	Sevin XLR Plus	1.25–2.5 L	0.5–1 L	2	
Aphids						
endosulfan[2]	chlorinated cyclodiene	Thiodan 50 WP	1–2.25 kg	0.4–0.9 kg	2	
		Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50W	1.1–2.25 kg	0.44–0.9 kg	2	
Tarnished Plant Bug						
dimethoate	organophosphate	Cygon 480	0.5–0.7 L	0.2–0.28 L	7	
		Lagon 480	0.5–0.7 L	0.2–0.28 L	7	
Colorado Potato Beetle						
Transplant Treatment						
imidacloprid	chloronicotinyl	Admire 240 F	7–10 mL per 100 m of row	2–3 mL per 100 ft of row	70	Maximum 1 application/yr. **Do not** follow transplant treatments with a foliar Admire application.
Foliar Treatments						
carbaryl	carbamate	Sevin XLR Plus	1.25–2.5 L	0.5–1 L	2	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1–2.25 kg	0.4–0.9 kg	2	
		Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50W	1.1–2.25 kg	0.44–0.9 kg	2	
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	80 mL	7	**Do not** use foliar applications following transplant treatments.

[1] DHI = Days to Harvest Interval.
[2] The green peach aphid is resistant to these insecticides in some areas.

Insects

CUTWORMS, TARNISHED PLANT BUG, WIREWORMS, APHIDS

For identification and management information on these common vegetable insects affecting eggplant, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–30, *Eggplant Disease and Insect Control Recommendations*, above.

COLORADO POTATO BEETLE

Identification: Adults are orange with 10 black stripes on the wings. Larvae are red-to-orange with two rows of black spots along their sides.

Period of Activity: Beetles are present all season. However, feeding damage is a larger concern early in the season when plants are small.

Thresholds: None established. Chemical controls are most effective when they are applied to small larvae.

Management Notes: Rotate away from solanaceous crops. Colorado potato beetle overwinter in the fields of host crops. Avoid planting eggplant adjacent to fields that had host crops the previous year.

If scouting indicates a need, apply insecticide as a border spray or full treatment. In-furrow transplant water treatments are also available. See Table 6–30, *Eggplant Disease and Insect Control Recommendations*, on page 100.

Warning

In a number of counties and regions, Colorado potato beetles have developed a strong resistance to a number of insecticides. To slow development of further resistance, it is essential for all growers to rotate between chemical groups each time a spray is applied.

FLEA BEETLES

Identification: Small, dark beetles cause "shot-hole" feeding damage on leaves.

Period of Activity: Begin monitoring for flea beetles as soon as the transplants are set in the field.

Thresholds: None established.

Management Notes: If beetles or feeding are found on the plants, apply one of the insecticides listed in Table 6–30, *Eggplant Disease and Insect Control Recommendations*, on page 100.

Nematode Control

See the section *Nematodes*, on page 57, for nematode control recommendations.

Harvest and Storage

Fruits should be harvested when they have reached marketable size but before the seeds begin to change colour. Fruits should be glossy and firm, not soft and spongy. Harvest by cutting the fruit from the plant. Handle carefully, as eggplant fruit bruises easily.

Store at 8°C–12°C (46°F–54°F) at a relative humidity of 90%–95% for up to 1 week.

GARLIC

Production Requirements

Garlic produces good yields on well-drained, deep, fertile soils. Extremely heavy soil types should be avoided. Low pH soils, (5.0–5.5 or less) will result in very poor yields and plant stands. Garlic is a winter annual, planted in fall and harvested the following summer. Harvest begins when the leaf tops begin to dry, discolour and bend towards the ground.

Average Yields

Crop	per acre	per hectare
Garlic	2,000 – 4,000 lb	2,000-4,500 kg

Cultivars

The recommended cultivars in Ontario are the Music strains.

Note: Cultivated garlic plants do not produce true seed. All garlic is propagated vegetatively. Two types of garlic are grown in Ontario and are described as either "hard-neck" or "softneck." Consult the Ontario Garlic Growers Association for seed sources (www.garlicgrowers.on.ca).

Seeding and Spacing

The optimum planting date is from September to late October, with October 15 being ideal most years. To estimate the planting date, use the average date for the first fall frost for the area in which garlic is to be grown and begin planting on this date. See Table 4–1, *Average Frost-Free Period in Climatic Zones of Ontario*, on page 37.

Row spacing:	20 cm (8 in.)
In-row spacing:	7–12 cm (3–5 in.) (wider in lighter, drought-prone soils)
Rate:	700–1,000 kg of cloves/ha (630–900 lb cloves/ac)
Depth of planting:	3–5 cm (1–2 in.) between the soil surface and the top of the clove

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.

On mineral soils, a total of 110 kg N/ha (99 lb/ac) is required. Calcium nitrate or calcium ammonium nitrate are the preferred sources. Apply half the nitrogen as soon as the garlic plants begin to grow in the spring. Apply the rest of the nitrogen in 2–3 side-dresses at 3-week intervals.

Phosphate and Potash

Use a soil test to establish pH, phosphorus and potassium requirements. Amend soil pH, phosphorus and potassium levels prior to fall planting.

Phosphorus and potassium requirements are similar to those for onions. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19).

Irrigation

Garlic is shallow-rooted and sensitive to moisture stress. For most soil types, approximately 2.5 cm (1 in.) of water is required per week. On very dry, sandy soils, as much as 5.0 cm (2 in.) is required weekly.

Integrated Pest Management

Seed Treatments

Many garlic seed treatments intended for crop protection and disease reduction have been tested; however, none have provided consistent results. The most reliable yields have been achieved by planting healthy, damage- and disease-free planting stock.

For more information on damping-off and root rots, see the section *General Insects and Diseases of Vegetable Crops*, on page 54.

Diseases

PENICILLIUM DECAY, GREEN MOULD

Identification: Infected cloves may fail to emerge in the spring or they may produce weak, stunted plants that soon die. The fungus frequently sporulates on the surface of decaying cloves, producing bluish-green masses of spores.

Period of Activity: The fungus attacks cloves in late fall and early spring, prior to emergence.

Thresholds: None established.

Table 6–31.
Garlic Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Penicillium or Green Mould Disease						
iprodione	dicarboximide	Rovral	4 g/L of water			Dip cloves into the Rovral suspension for 30 minutes immediately before planting.
Sclerotinia White Rot						
dicloran	quinone	Botran 75 W	6.75–11.0 kg	2.7–4.4 kg		**Spring Planting** Apply 1–2 weeks prior to planting and work into top 4 cm (1.5 in.) of soil.
			36.0–44.0 kg	14.4–17.6 kg		**Fall Planting** Apply 1–2 weeks prior to planting and work into top 4 cm (1.5 in.) of soil.
Aphids, Thrips						
malathion	organophosphate	Malathion 500 E	1.1–2.75 L	0.44–1.1 L	3	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	188 mL	75.2 mL	14	**Thrips only.** Do not use more than 3 times per season. 24-hr re-entry period.
Onion Maggot						
chlorpyrifos	organophosphate	Lorsban 4E	3.5 L in 1,000 L of water	1.4 L in 400 L of water	50	Apply as a drench over the row on newly emerged plants (in the spring).
		Pyrinex 480 EC	3.5 L in 1,000 L of water	1.4 L in 400 L of water	50	Apply as a drench over the row on newly emerged plants (in the spring).

[1] DHI = Days to Harvest Interval

Management Notes: Plant clonal cultivars known to be vigorous under Ontario growing conditions. Avoid damaging the seed cloves, especially during the cracking procedure. Many mechanized cracking devices cause excessive amounts of clove damage.

Cloves may be treated with one of the fungicides listed in Table 6–31, *Garlic Disease and Insect Control Recommendations*, above.

FUSARIUM BASAL ROT AND SCLEROTINIA WHITE ROT

See the sections *Fusarium Basal Rot*, on page 116, and *Sclerotinia White Rot*, on page 115. Sclerotinia white rot control options are listed in Table 6–31, above.

Insects

WIREWORM, APHIDS

For identification and management information on these common vegetable insects affecting garlic, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–31, *Garlic Disease and Insect Control Recommendations*, above.

LEEK MOTH

Identification: In Eastern Ontario and Quebec, there have been reports of leek moth damage from a limited number of organic garlic producers. The larvae tunnel mines and create pinholes in the leaf tissue, sometimes causing distortion. They occasionally attack the bulb, stem and the scape. Damage to garlic cloves may predispose them to secondary bacterial or fungal diseases.

Larvae are yellowish-green with eight small, greyish spots on each segment, with a pale-brown head capsule. They reach 13–14 mm (½ in.) at maturity. The reddish-brown pupa is encased in a loosely netted cocoon. Cocoons are usually found on the leaves.

Period of Activity: There is little scientific information regarding the biology of this new pest in Ontario and Quebec. There are possibly two to three generations per summer, although this remains to be verified under field conditions. Information from Europe indicates the insect overwinters as an adult moth in various sheltered areas (buildings, hedges, plant debris, etc.). They emerge in the spring when temperatures reach 9.5°C (49°F) and mate shortly thereafter.

Management Notes: At present, there are no registered pest control products in Canada for management of leek moth. Insecticide applications used to control other crop pests (onion maggot, thrips, etc.) may also reduce leek moth damage.

For further information, visit the OMAF Web site at www.omaf.gov.on.ca.

ONION THRIPS AND ONION MAGGOTS

See the sections *Onion Thrips* and *Onion Maggot*, on page 117. Control options are listed in Table 6–31, *Garlic Disease and Insect Control Recommendations*, on page 103.

Harvest and Storage

Harvesting begins when the leaf tops begin to dry, discolour and bend towards the ground. Another indication of bulb maturity is the reduced thickness of the sheath leaves surrounding the bulb.

For maximum storage life (5–8 months), garlic should be properly cured and stored at 0°C (32°F) and 60%–70% relative humidity. Higher humidity promotes the development of *Penicillium* and undesirable root growth. As storage temperatures are increased above 0°C (32°F), the rate of bulb weight loss increases.

For further information consult the OMAF Factsheet, *Garlic Production*, Order No. 97-007.

HERBS

Production Requirements

In general, herbs do best in full sunlight (chervil requires partial shade), in a protected location. They are best suited to well-drained, sandy loam soils that are slightly acidic and fertile. (Thyme prefers calcareous soils.) Excessive fertility can reduce essential oils and fragrances in the leaf tissue of actively growing herbs.

Propagation

Methods of propagation vary dramatically. Each herb type may require specialized treatment for germination rate and seedling vigour. The method of propagation may vary depending on whether the supplier is offering bunches, custom orders or trays of live plants. It is essential to procure proper strains of certain herbs such as French tarragon. Purchase stock only from sources using marketable strains. See Table 6–32, *Herb Type, Propagation, Parts Harvested/Sold*, right.

Overwintering Perennial Herbs

Straw mulching (wheat preferred) may be used to protect roots during the dormant season for perennials.

Fertility and Irrigation

Soils should be moderately fertile. A regular soil test should form the basis of any fertility program as well as regular incorporation of organic matter. Excessive use of nitrogen will produce weakly flavoured leaf and stem tissue. Herbs are generally more drought-tolerant than most vegetable crops. Water only when signs of wilt are evident. Mint may require irrigation at key times during production.

Field Spacing

Space needs can vary considerably between the herbs. In-row spacing can vary from 20 cm (8 in.) for anise, parsley or sweet marjoram to 75 cm (30 in.) for coriander, dill, fennel and rosemary. Between-row spacing can vary from 90–120 cm (36–48 in.), depending on cultivation practices.

Disease and Insect Management

Insects and diseases (such as mildew in rosemary or septoria leaf blight, bacterial blight and clover worm in parsley) can affect many herbs. Various leaf-feeding caterpillars and aphids can be found on many species. Regular scouting activity can detect an outbreak of a certain pest before a serious infestation results. See Table 6–33, *Herb Cabbage Looper Control Recommendations*, on page 106.

Table 6–32.
Herb Type, Propagation, Parts Harvested/Sold

Herbs	Propagation	Leaves		Whole Shoot		Ripe, Dry Fruit	Flowers
		Fresh	Dried	Fresh	Dried		
Annuals							
Anise	S[1]	X				X	
Borage	S[1]	X	X			X	X
Caraway	S					X	
Chervil	S[1]	X	X	X	X		
Coriander	S[1]	X	X			X	
Dill	S[1]	X	X	X		X	
Fennel	S[1]	X	X	X	X	X	
Parsley[2]	S[1]	X	X				
Sweet basil	S[3]			X	X		
Sweet marjoram	S[3]				X		
Summer savory	S				X		
Perennials							
Chives (bulb)	C, R, S[3]	X	X				
Lavender	C, R, S[4]						X
Lemon verbena	C, R	X	X				
Mint	C, R	X	X	X	X		
Oregano	C, R, S[3]				X		
Rosemary (non-hardy)	C, R, S[4]	X	X				X
Sage	C, R, S[3]	X	X	X	X		
Tarragon	C, R				X		
Thyme	C, R, S[3]				X		

C = cutting; S = seed; R = root division

[1] Direct seeding is best for field production.
[2] See the section *Lettuce, Endive & Parsley*, on page 107.
[3] Direct seeding or transplants (plugs) are best for field production.
[4] Use transplant plugs for field production.

Competition Control and Mulching

A variety of methods of weed control are practised in herb plantings. Cultivation is perhaps the most useful tool. Plastic mulch in combination with drip irrigation may be useful in some situations.

Table 6–33.
Herb Cabbage Looper Control Recommendations[1]

Common Name	Group	Trade Name	Rate per hectare	Rate per acre	DHI[2]	Notes
Bacillus thuringiensis	biological	Dipel 2X DF	275–550 g	110–220 g	0	Apply to control small larvae. Maximum 5 applications/yr.
		Bioprotec CAF	1.4–2.8 L	0.56–1.1 L	0	

[1] Including mints, celery seed, parsley (dried), mustard seed, nasturtium, basil, caraway, catnip, chervil (dried), coriander, dill and fennel.
[2] Days to Harvest Interval

Harvesting for Fresh Market and Dry Market

If practical, harvest in early morning after the dew has dried from the crop and before the sun dissipates the essential oils; leaves should be clean and free of dust and soil. Do not completely strip the stems of the entire leaf crop, as remaining leaves are necessary to keep the plants growing.

For more information, see the OMAF Factsheet, *Growing Culinary Herbs in Ontario*, Order No. 02-049.

LETTUCE, ENDIVE & PARSLEY

Production Requirements

Lettuce, endive and parsley are cool-season vegetables. They grow best at temperatures between 13°C–18°C (55°F–64°F). Germination occurs even at temperatures as low as 4°C (39°F). Germination is delayed at very high soil temperatures (≥27°C or 81°F).

On mineral soils, production is limited to the transplanted early crop and the seed-sown late crop. On muck soils, in cooler areas such as Bradford, leafy green crops may be produced throughout the growing season.

Average Yields

Crop	per acre	per hectare
Head lettuce (crisphead, butterhead	800–1,000 cases (25,000–40,000 lb)	2,000–2,500 cases (28,000–45,000 kg)
Cos lettuce (Romaine)	1,000–1,200 cases (25,000–40,000 lb)	2,500–3,000 cases (28,000–45,000 kg)
Leaf lettuce	12,000–16,000 lb	13,500–18,000 kg
Endive / escarole	12,000–16,000 lb	13,500–18,000 kg
Parsley	700–1,100 bushels	1,500–2,500 bu

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Planting, Seeding and Spacing

Use coated or pelleted seed with a precision seeder to ensure a more uniform stand. This also reduces thinning costs and provides higher percentages of cut at harvest time.

Seeding time is important for the late crop on both muck and mineral soils. If plants are immature when the first frost occurs, they will recover. Wrapper leaves on mature heads are very susceptible to frost and can only be marketed at a lower grade.

Properly hardened transplants, when set in the field in the early spring, can tolerate temperatures as low as –7°C (19°F). See the section *Vegetable Transplants*, on page 175.

Plant approximately 1–2 kg (1.5 lb) of seed/ha. See Table 6–34, *Lettuce, Endive and Parsley Spacing and Seeding Rates*, right.

Table 6–34.
Lettuce, Endive and Parsley
Spacing and Seeding Rates

	Row Spacing cm (in.)	In-Row Spacing cm (in.)
Butterhead and leaf	30 (12)	20–30 (8–12)
Crisphead	40 (16)	30–35 (12–14)
Endive	40 (16)	20–30 (8–12)
Parsley	30–40 (12–16)	10–15 (4–6)

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.

Broadcast and incorporate the recommended preplant nitrogen with the required potash and phosphate. On mineral soils, side-dress the remaining nitrogen 3 weeks after transplanting or thinning the crop. See Table 6–35, *Lettuce Nitrogen Recommendations*, below.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

If phosphate and potash are required, apply and incorporate them prior to planting.

Table 6–35.
Lettuce Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral soils		
Preplant broadcast	55	49
Side-dress	55	49
Total	**110**	**98**
Muck soils		
Preplant broadcast[1]	120	107

[1] Reduce to 100 kg/ha (107 lb/ac) for mid- to late-season plantings.

Table 6–36. Lettuce Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Ridomil 2G	metalaxyl	25 kg/ha (10 kg/ac)	damping-off, pythium stunt	Apply with seed in-furrow. Use 115 g per 100 m of row. Do not use on transplants.
Thiram 75 WP	thiram	90 g/25 kg of seed	damping-off	

Secondary and Micronutrients

COPPER

Copper (Cu) deficiency may show up on acid peat and muck soils. Mix copper with the fertilizer and apply at 14–29 kg Cu/ha (12.5–25 lb/ac) on newly cultivated muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck. See the section *Copper*, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

MANGANESE

Manganese-deficient lettuce shows marked yellowing between the veins, which remain dark green. Manganese deficiency usually shows up on slightly acid or alkaline muck, peat and dark-coloured sandy soils. Soil application is not recommended for manganese because of the large amounts required. If a deficiency is identified, apply foliar manganese sprays starting after thinning or transplanting. For more information, see the section *Manganese*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

CALCIUM

Under hot, dry conditions, lettuce may benefit from calcium to prevent tipburn or blackheart symptoms. See the section *Calcium*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

See OMAF Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, for a comprehensive guide to IPM for lettuce.

Diseases

DAMPING-OFF AND ROOT ROTS

For more information on damping-off and root rots, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. For lettuce crops, also see Table 6–36, *Lettuce Seed Treatments*, above.

BOTRYTIS GREY MOULD

Identification: White-to-grey downy fungi first develop on older, outer leaves. This rapidly reduces the leaf to a water-soaked, slimy mass of tissue and causes the plant to completely collapse.

Period of Activity: Grey mould overwinters in the soil and on plant debris. Rapid fungal growth occurs in damp weather with temperatures of 18°C–23°C (64°F–73°F).

Thresholds: None established.

Management Notes: Fungicides can be effective but it is very difficult to get adequate coverage of the lower leaves, where infection first occurs. Grow on raised beds to increase air movement and decrease disease pressure. Follow a good crop rotation. See Table 6–37, *Lettuce and Parsley Disease Control Recommendations*, on page 109.

DOWNY MILDEW

Identification: Infection usually begins on the mature leaves and spreads inward toward the central leaves. Chlorotic (yellowish) or pale-green areas appear on the upper surface of the leaves. White, velvety areas are found on the lower leaf surface. Infected tissue usually dies.

Period of Activity: The fungus overwinters in wild lettuce plants and crop debris. Spores are spread by wind or splashing rain. For germination to occur, the leaf surface must be moist. The optimum temperature for infection occurs between 15°C–20°C (59°F–68°F). The time from infection to the production of new spores varies from 5–18 days.

Thresholds: None established.

Management Notes: Select resistant cultivars and follow a 2–3-year crop rotation. Plowing infected residue may reduce the soil inoculum. See Table 6–37, on page 109.

LETTUCE DROP (SCLEROTINIA WHITE MOULD)

Identification: Lettuce drop (wilting of the entire plant) is most often observed as plants approach maturity. The limpness of the entire plant resembles the symptoms of grey mould. Cottony-white fungi develop on the underside of the lower leaves. Black sclerotia are often embedded within it.

Period of Activity: The long-lived sclerotia overwinter in the soil and on plant debris. Lettuce drop is most prevalent during cool, wet weather.

Thresholds: None established.

Table 6–37.
Lettuce and Parsley Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Botrytis Grey Mould						
Greenhouse-grown seedlings						
ferbam	dithiocarbamate	Ferbam 76 WDG	2 kg/1,000 L water			Spray 76% solution to wet plants only.
Field application						
iprodione	dicarboximide	Rovral	1.5 kg	0.6 kg	4	Maximum 4 applications/yr. Start after thinning, apply at 7-day intervals.
boscalid	anilid	Lance WDG	285 g	114 g	14	Maximum 2 applications/yr.
Downy Mildew						
zineb	dithiocarbamate	Zineb 80 W	2.25–2.5 kg	0.9–1 kg	10	Lettuce only.
metalaxyl-m/ mancozeb	acylamine & dithiocarbamate	Ridomil Gold MZ 68 WP	2.5 kg	1 kg	14	Lettuce only. Maximum 3 applications/yr.
fosetyl-al	phosphonate	Aliette WDG	2.8 kg	1.12 kg	7	Lettuce only. Maximum 5 applications/yr. 12-hr re-entry period.
Lettuce Drop (Sclerotinia White Mould)						
dicloran	quinone	Botran 75 W	2.3–3.75 kg	0.9–1.5 kg	14	Lettuce only. Maximum 2 applications/yr.
vinclozolin[2]	dicarboximide	Ronilan EG	1.1 kg	0.44 kg	28	Lettuce only. 12-hr re-entry period. Maximum 3 applications/yr.
boscalid	anilid	Lance WDG	385 g	154 g	14	Maximum 2 applications/yr.
Phytophthora (in Belgian Endive)						
metalaxyl-m/ mancozeb	acylamine & dithiocarbamate	Ridomil Gold MZ 68 WP	1 kg	0.4 kg	—	One application to Belgian endive roots immediately after harvest. **Do not** apply within 21 days of sale of the roots.

[1] Days to Harvest Interval.
[2] Apply 12 days after thinning on seeded crop or 57 days after transplanting. Second and third applications may be made at 10-day intervals. Note that a 15-m buffer zone must be maintained between sprayed areas and aquatic systems such as ponds and ditches.

Management Notes: Follow a 2–3-year rotation with non-susceptible crops such as onions, beets or spinach. Good drainage and growing lettuce on raised beds improves drainage and increases air movement around the plants. Flooding infested land for 3–4 weeks causes the breakdown of sclerotia and may reduce soil populations.

See Table 6–37, *Lettuce and Parsley Disease Control Recommendations*, above.

SEPTORIA LEAF SPOT

Identification: This disease causes greyish-brown spots with chlorotic margins on leaves and petioles. Small (pinpoint) black pycnidia can be found in the lesions.

Period of Activity: Pycnidia are carried on seed, in crop residues and on weed hosts. Spores germinate at temperatures above 12°C (54°F). Infection requires the presence of water or high humidity (greater than 90% relative humidity) for 24 hours.

Management Notes: Seed-borne infections decrease in 2-year old (or older) seed. Bury infected crop residues and follow a 2–3-year rotation to reduce soil-borne infections.

RHIZOCTONIA BOTTOM ROT

Rust-coloured sunken lesions appear on the midrib of lower leaves. Bottom rot is most commonly observed on mineral soils. The fungus is active during warm, humid weather. Rotate with legumes, cereals, grasses or other non-host crops. Plant in areas with good soil drainage and avoid fields with a history of bottom rot. Growing lettuce on raised beds will improve air circulation near the plant base, where infection is likely to begin.

CORKY ROOT ROT

Yellow lesions appear on the roots. These lesions enlarge until the entire tap root is brown, rough and cracked. The disease builds up with continual lettuce cropping. This problem can also be caused by excess nitrogen. It is more severe in warm conditions and in summer and fall crops.

Allow sufficient time between lettuce crops for the plant residues to decompose completely. Avoid applying excessive amounts of nitrogen, especially urea. Raised beds

Table 6–38.
Lettuce and Parsley Aphid Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
dimethoate	organophosphate	Cygon 480	700 mL	280 mL	7	Lettuce only.
		Lagon 480	700 mL	280 mL	7	
pirimicarb	carbamate	Pirimor 50 DF	300–500 g	120–200 g	7	Lettuce only.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	0.8 L	14	Head lettuce only. Maximum 3 applications/yr.
		Endosulfan 50W	1.75 kg	0.7 L	14	
methamidophos	organophosphate	Monitor 480	1.1–2.25 L	0.44–0.9 L	14	Head lettuce only. 48-hr re-entry period.
naled[2]	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	Lettuce, endive only.
diazinon[3]	organophosphate	DZN 600 EW	915 mL	366 mL	10	Lettuce only.
					14	Parsley only.
		Diazinon 500 E	1.1 L	0.44 L	10	Lettuce only.
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	7	Head lettuce only. Maximum 4 applications/yr.
imidacloprid	chloronicotinyl	Admire 240 F	10.2 mL per 1,000 plants	10.2 mL per 1,000 plants	21	**Transplant tray plug drench.** Do not follow transplant drench with soil or foliar treatments.
		Admire 240 F	650 mL	260 mL	21	**Soil application (field drench).** Apply after transplanting using 2,000 L water/ha. Maximum 1 application/yr.
		Admire 240 F	200 mL	80 mL	7	**Foliar application.**[3] Do not make Admire foliar application following a plug treatment or soil drench application. 24-hr re-entry period.
acetamiprid	chloronicotinyl	Assail 70 WP	56–86 g	22.4–34.4 g	7	Lettuce, endive, parsley and leafy greens Maximum 5 applications/yr. Alternate applications with other insecticide families.

[1] DHI = Days to Harvest Interval.
[2] Control of aphids with naled and diazinon has been inconsistent in many areas.
[3] One application of Admire 240 F per crop and a maximum of 2 foliar applications per *field* per year are permitted.

and reduced irrigation are recommended to encourage deep rooting. Resistant cultivars are available.

BACTERIAL WILT, DRY LEAF SPOT

Bacterial wilt is a seed-borne pathogen. Water-soaked, wedge-shaped spots form along the leaf margins. Spots may become olive coloured. Bacterial wilt requires a wound, such as frost injury or mechanical damage, to infect healthy plants. Excessive nitrogen or overhead irrigation may increase disease levels. Follow good sanitation practices in all greenhouse areas used for transplant production.

LETTUCE MOSAIC VIRUS

Leaves develop chlorotic, yellow spotting. Plants grown from infected seed or infected early in their development have pale green-to-yellow mottled leaves. Lettuce mosiac is primarily seed-borne. However, it can also be transmitted by aphids.

Mosaic-indexed or mosaic-tested seed is available from most sources. This seed is produced in special areas where it is carefully checked to ensure that it is virtually free from seed-borne mosaic. Control aphids, which spread the disease from infected lettuce plants. Weeds such as groundsel, shepherd's-purse and lamb's-quarters are alternate hosts.

ASTER YELLOWS

Transmitted by the aster leafhopper, aster yellows causes a bright yellowing and twisting of leaves. Infected crisphead types suffer poor head formation. Secondary bacterial rots often follow aster yellows. See the section *Aster Leafhopper*, on page 111, for control recommendations.

Insects

APHIDS, CUTWORMS, TARNISHED PLANT BUG

For identification and management information on these common vegetable insects affecting lettuce, endive and parsley, see *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–38, *Lettuce and Parsley Aphid Control Recommendations*, above. Also see Table 6–39, *Lettuce, Endive and Parsley Insect Control Recommendations*, on page 111.

Table 6–39.
Lettuce, Endive and Parsley Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cutworms						
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	21	Do not disturb soil for 5 days after treating.
permethrin	pyrethroid	Pounce	180–390 mL	72–156 mL		Apply up to the 5-leaf stage. Do not disturb soil for 5 days after treating. Use high rates on muck soils.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33 mL	3	Head lettuce only. 24-hr re-entry. Maximum 3 applications/yr. Dark-sided and white cutworms only.
Aster Leafhopper						
cypermethrin	pyrethroid	Ripcord 400 EC	125 mL	50 mL	14	Lettuce only. Maximum 4 applications/yr.
		Cymbush 250 EC	200 mL	80 mL	14	
malathion	organophosphate	Malathion 500 E	1.5–2.75 L	0.6–1.1 L	3	Head lettuce.
					14	Leaf lettuce.
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1 L	5	Head lettuce.
					21	Leaf lettuce, endive, parsley.
Cabbage Looper						
Bacillus thuringiensis	microbial	Dipel 2XDF	275–550 g	110–220 g	0	Lettuce & parsley only. 275 g/ha rate maximum for parsley.
		Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	Lettuce only.
methomyl	carbamate	Lannate	0.51–1.0 kg	0.2–0.4 kg	7	Head lettuce only. 24-hr re-entry period.
methamidophos	organophosphate	Monitor 480	1.25–2.25 L	0.5–0.9 L	14	Head lettuce only. 48-hr re-entry period.
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	Lettuce & endive only.
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	0.8 L	14	Head lettuce only. Maximum 3 applications/yr.
		Endosulfan 50 W	1.75 kg	0.7 kg	14	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.9 kg	7	Head lettuce only. Maximum 4 applications/yr.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33 mL	3	Head lettuce only. Maximum 3 applications/yr. 24-hr re-entry period.
spinosad	naturalyte	Success 480 SC	182 mL	73 mL	1	Maximum 3 applications/yr.
Tarnished Plant Bug						
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	0.8 L	14	Head lettuce only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33 mL	3	Head lettuce only. Maximum 3 applications/yr. 24-hr re-entry period.
carbaryl	carbamate	Sevin XLR plus	2.5–5.25 L	1–2.1 L	5	Head lettuce.
					21	Leaf lettuce, endive, parsley.

[1] DHI = Days to Harvest Interval.

ASTER LEAFHOPPER

The aster leafhopper transmits aster yellows. See the aster yellows (AYI) calculation in the section *Aster Leafhopper*, on page 75.

Treat when the AYI equals 20–25 for head lettuce or 30–35 for romaine. See Table 6–39, *Lettuce, Endive and Parsley Insect Control Recommendations*, above.

PEA LEAF MINER

The pea leaf miner (PLM) has been found in the Holland Marsh area of Ontario. Larvae feed between the upper and lower surface of the leaves, reducing photosynthetic capacity. The mines also affect marketability and provide an entrance for disease organisms. Leaf miners are most likely to attack head and leaf lettuce types. For more information, see the section *Leaf Miners*, on page 80.

CABBAGE LOOPER

While this is a rare problem, the cabbage looper can cause sporadic damage in lettuce, endive and parsley. Five percent infestation is the suggested control threshold. See Table 6–39, *Lettuce, Endive and Parsley Insect Control Recommendations*, above.

For more information on pest management in leafy green crops, consult the following OMAF Factsheets and publication:

- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*
- *The Aster Leafhopper and Aster Yellows*, Order No. 98-057
- *Aphids Infesting Lettuce and Celery in Ontario*, Order No. 00-053
- *Leaf Miners Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039
- *Caterpillar Pests of Crucifer Crops*, Order No. 99-035
- *Tarnished Plant Bug Damage on Vegetable Crops in Ontario*, Order No. 98-025

Nematode Control

See the section *Nematodes*, on page 57, for nematode control recommendations.

Harvest and Storage

Lettuce and leafy green crops are usually harvested by hand and packed into cartons in the field. Mechanical harvesters are now available.

Leafy green crops are not adapted to long-term storage. To achieve a 2–3-week storage life, maintain a temperature of 0°C (32°F) and 95%–100% relative humidity. Vacuum cooling or hydrocooling can help maintain a fresh appearance. Cracked ice used in or around packages will help maintain quality.

ONIONS, LEEKS & SHALLOTS

Production Requirements

Allium species (onions, leeks, shallots, chives, etc.) grow in a wide range of soil types. Alliums tend to grow best on mineral soils with a pH range of 5.8–7.0 and on muck soils with a pH range of 5.0–6.0. Alliums mature in 75–120 days.

Average Yield

Crop	per acre	per hectare
Dry onions (cooking, Spanish)	600–1,000 #50 bags	1,500–2,500 #50 bags
Bunching (green) onions	900–1,200 lb (4,000 dozen)	1,000–1,500 kg (10,000 dozen)
Leeks	500 cases[1]	1,250 cases[1]
Shallots	9–12 tons	20–27 tonnes

[1] 1 case = 24 bunches of 3 leeks each

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

In Ontario, summer and autumn leek are grown. Two types of shallots are generally available: the French-Italian (brownish-red skin is the most commonly grown) and the Welsh shallot (green shallot).

Spacing and Seeding

The optimum planting depth ranges from 0.5–2.5 cm (¼–1 in.). Use shallow seeding on heavy mineral or crust-prone soils. In drier soil and in areas where wind and water erosion are problems, sow seeds at a depth of 3–4 cm (1¼–1½ in.).

To achieve an earlier crop, dry bulb onions can be grown in plug trays and planted into the field when soil conditions permit. Transplants have some advantages in managing disease and weeds, as well as producing an earlier crop. See the section *Vegetable Transplants*, on page 175.

See Table 6–40, *Allium Species Spacing and Seeding Rates*, below.

Irrigation

Allium species have shallow, limited root systems. The critical water-use period lasts up to, and including, the bulb formation stage. Do not permit the soil moisture to fall below 50%. The plants should receive 2.5 cm (1 in.) of water a week, either as rainfall or irrigation. Irrigation after bulb maturity may not be beneficial and may reduce yield and/or quality.

Irrigation may not be necessary on deep muck soils. Maintain the water table at 85 cm (2.5 ft) below the soil surface.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.

Broadcast and incorporate the recommended preplant nitrogen with the required potash and phosphate. On muck soils, apply the recommended side-dress nitrogen when plants are 8–10 cm (3–4 in.) tall (see Table 6–41, *Onion Nitrogen Recommendations*, on page 114).

Table 6–40.
Allium Species Spacing and Seeding Rates

Crop	Row Spacing cm (in.)	In-Row Spacing cm (in.)	Rate kg/ha (lb/ac)
Dry bulb (cooking and Spanish)	35–43 (14–17)	2.5–3.5 (1–1.5)	4–4.5 (3.5–4)
Bunching (green)	30–38 (12–15)	1–2.5 (0.5–1)	7 (6)
Dry bulb transplants (cooking and Spanish)	35–43 (14–17)	10–12.5 (4–5)	1.7–3.5[1] (1.5–3)
Leeks (transplants)	60–90 (24–35)	10–15 (4–6)	1.1–2.2[1] (1–2)
Pickling onions			35–45 (31–40)
Shallots	46–60 (18–24)	7.5–10 (3–4)	220–330[2] (200–300)

[1] Listed seeding rates will produce enough transplants for 1 ha (1 ac).
[2] Bulbs.

Table 6–41.
Onion Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral Soils		
Apply up to	110	98
Muck Soils		
Preplant	90	80
Side-dress	30	27
Total	**120**	**107**

On shallow muck soil or soils with a high proportion of mineral soil, use 200 kg/ha (180 lb/ac) monoammonium phosphate (MAP), applied 5–7.5 cm (2–3 in.) below the seed. Reduce the broadcast fertilizer by 22 kg/ha (20 lb/ac) nitrogen and 96 kg/ha (86 lb/ac) phosphate.

Leeks require higher amounts of nitrogen than onions, normally around 200 kg N/ha (180 lb/ac), applied in three instalments: one preplant and two side-dressings.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils* and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19).

If phosphate and potash are required, apply and incorporate them prior to planting.

Micronutrients

COPPER

Copper deficiency occurs on acid, peat and muck soils. Bulbs show poor-coloured skins. Copper may be mixed with the fertilizer and applied at 14–29 kg Cu/ha (12.5–26 lb/ac) on newly cultivated muck. Subsequent applications may be made every 2 or 3 years at about one-third the rate recommended for new muck.

MANGANESE

Manganese deficiency shows up as a yellowing between the leaf veins. See the section *Manganese*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

MOLYBDENUM

Molybdenum deficiency may occur when onions are grown on moderately acid to strongly acid muck soils. A seed treatment has proven beneficial. The treatment is accomplished by dissolving 15 gm of sodium molybdate in 45 mL of water. Spray this solution from an atomizer bottle on 2.3 kg seed (1 lb) spread thinly on a plastic sheet. Do not use excessive water as this can cause the chemical to penetrate the seed embryo and cause injury. Mix the seed thoroughly and let dry. For foliar application rates, see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

ZINC

Zinc deficiency shows up as a stunting and marked twisting and bending of yellow-striped foliage. It occurs mainly with shallow muck soils or where the calcareous subsoils are mixed with the muck. See the section *Zinc*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

See OMAF Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*, for a comprehensive guide to IPM for onions.

Diseases

DAMPING-OFF AND ROOT ROTS

For more information, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–42, *Onion Seed Treatments*, below.

Table 6–42.
Onion Seed Treatments

Trade Name	Active Ingredients	Rate	*Pests Controlled	Notes
Apron XL LS	metalaxyl-m	20 mL per 100 kg seed	damping-off	For use in commercial seed treatment plants only.
Thiram 75 WP	thiram	65–80 g per 25 kg seed	damping-off	
Pro-Gro	carbathiin-thiram	25 g per 1 kg seed	smut	Pro-gro treated seed may be stored for up to 4 months.
Govenor 75 WP	cyromazine	66.7 g per 1 kg seed	onion maggot	Imported seed only. Only on muck soils. Do not plant treated seed in the same field in consecutive years.

BOTRYTIS LEAF BLIGHT

Identification: White, oval-shaped spots with silvery halos develop on the leaves. Lesions are 1–5 mm long. Severely infected leaf tips die back. Infection is more likely to occur if the leaves are injured, bruised or starting to senesce.

Period of Activity: Botrytis leaf blight typically develops after mid-June when temperatures and leaf-wetness periods are sufficient for infection to occur.

Thresholds: A forecasting model called BOTCAST has been developed to help predict botrytis leaf blight outbreaks.

DOWNY MILDEW

Identification: Infections usually occur in patches within the field. A violet or greyish growth develops, and the tissue dies quickly, resulting in straw-coloured lesions and eventual plant death.

Period of Activity: This disease is more common in cool, wet seasons. Infection occurs when the foliage remains wet for 2–6 hours at 3°C–14°C (37°F–57°F). The incubation period lasts for 10–16 days. A relative humidity of 95% or greater will also promote further infections.

Thresholds: A forecasting model called DOWNCAST has been developed to help predict downy mildew outbreaks.

PURPLE BLOTCH

Identification: The 1–3 cm (0.5–1 in.) spots are brown with reddish-purple margins. There may be a yellow zone around the lesions. Infected leaves may be weakened and easily blown over.

Period of Activity: Infection occurs when warm weather, 18°C–30°C (64°F–86°F), coincides with prolonged dews or leaf wetness. Weaker plants or those affected by other diseases are at highest risk.

Thresholds: None established.

Botrytis, Downy Mildew and Purple Blotch Management Notes

All three of these diseases overwinter in crop debris. Dormant *Botrytis* sclerotia can remain alive for many years. Practice a 2–3-year crop rotation and remove cull onions from the field. See Table 6–43, *Allium Disease Control Recommendations*, on page 116.

ONION SMUT

Identification: Most fields in muck soils are infested with onion smut spores. When untreated, resulting losses may be as high as 50%–80%. Infected plants appear thickened, darker and slightly twisted. Cut leaves expose a mass of black teliospores on the inside. Most plants die within 3–4 weeks of infection.

Period of Activity: The smut spores are long-lived and may last up to 20 years in the soil. Infection occurs at 10°C–12°C (50°F–54°F) within 2–3 weeks of seeding.

Thresholds: None established.

Management Notes: The only practical means of controlling onion smut is the use of seed treatments or fungicides in the seed furrow. See Table 6–42, *Onion Seed Treatments*, on page 114, and/or Table 6–43, *Allium Disease Control Recommendations*, on page 116.

BOTRYTIS NECK ROT AND SMUDGE

Identification: Botrytis-infected bulb tissue becomes greyish. Mould may also develop. Black sclerotia eventually appear in the affected tissue. The smudge fungi form black concentric rings near the neck and on the outer scales of the bulb.

Period of Activity: Both botrytis neck rot and smudge are most commonly found on bulbs after harvest, but they can also appear on maturing bulbs in the field. The fungi of both diseases can survive in the soil for several years. Smudge prefers warm, wet weather. Botrytis infections occur during cool, wet conditions.

Management Notes: Follow a 2–3-year crop rotation and remove cull onions from the field. Proper curing and drying of onions reduces disease development in storage. Artificial heat curing may reduce problems in humid areas of the province. Onions with thick necks, nicks or bruises should be graded-out prior to storage. Most commercial onion cultivars are susceptible to neck rot, particularly Spanish and white types. Yellow and red-skinned onions are resistant to smudge.

SCLEROTINIA WHITE ROT

Identification: Foliar symptoms include yellowing, wilting and stunted plants. White fungal growth with small pinhead-sized sclerotia may be visible at the base of the plant. The fungus causes a watery rot and disintegration of the bulb. This disease is not always present at harvest but may show up in storage.

Period of Activity: The sclerotia and mycelium overwinter in soil and plant debris. Soil infested with sclerotinia white rot is spread by machinery, animals, pallet boxes,

Table 6–43.
Allium Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Downy Mildew, Botrytis Leaf Blight, Purple Blotch						
zineb	dithiocarbamate	Zineb 80 W	2–2.75 kg	0.8–1.1 kg	7	Onions only.
mancozeb	dithiocarbamate	Dithane	2.25–3.25 kg	0.9–1.3 kg	10	Labelled for dry onions only.
		Manzate 200 DF	2.25–3.25 kg	0.9–1.3 kg	10	
		Penncozeb 80 WP	2.25–3.25 kg	0.9–1.3 kg	10	
iprodione	dicarboximide	Rovral[2]	0.75 kg	0.3 kg	15	Onions only.
chlorothalonil	chloronitrile	Bravo 500	2.4–4.8 L	0.96–1.92 L	7	Dry bulb. **Botrytis leaf blight only.** Maximum 3 applications/yr.
					14	Green bunching. **Botrytis leaf blight only.** Maximum 5 applications/yr.
metalaxyl-m/ mancozeb	acylamine & dithiocarbamate	Ridomil Gold MZ 68 WP	2.5 kg	1 kg	7	Onions only. **For downy mildew only.** Apply before first outbreak of disease.
fosetyl-al	phosphonate	Aliette WDG	2.8 kg	1.12 kg	7	Onions only. **For downy mildew and purple blotch.** Maximum 5 applications/yr. 12-hr re-entry period.
boscalid	anilid	Lance WDG	475 g	190g	7	**For purple blotch and botrytis.** Maximum 6 applications/yr. Do not apply more than 2 sprays before rotating to a different fungicide family
pyraclostrobin	strobilurin	Cabrio EG	560–840 g	224–336 g	7	**For purple blotch and downy mildew only.** Maximum 3 applications/yr. Do not apply more than 2 sprays before rotating to a different fungicide family.
Smut						
mancozeb	dithiocarbamate	Dithane	4.4–8.8 kg	1.76–3.5 kg	100	Apply in furrow at seeding time. Use high rate only where smut pressure is high.

[1] DHI = Days to Harvest Interval.
[2] Rovral when tank-mixed with label rates of maneb or mancozeb will control botrytis leaf blight and downy mildew. Apply on a preventative basis. This tank-mix combination will help reduce the chance of resistance to Rovral.

wind and water. Warm soil temperatures, greater than 24°C (75°F) are less conducive to sclerotinia white rot.

Management Notes: Sclerotinia white rot can survive in the soil for many years. Wash all implements used in an infested field. Remove cull onions from field areas. Field flooding followed by crop rotation has been shown to reduce sclerotinia white rot in muck soils. Recent research indicates that sclerotial germination stimulants (such as garlic oil, dailly disulphides, etc.) can significantly reduce sclerotinia white rot.

PINK ROOT

Identification: This disease is present in many areas. It will not affect the yields of healthy crops, grown on quality soils. Infected roots have a pinkish-red colour and eventually turn purplish-black. The root system may be substantially reduced, causing the plant to turn yellow, wither and become stunted.

Period of Activity: The fungus can survive in the soil for several years in the absence of host plants. It mainly attacks the roots when soil temperatures rise to 26°C (80°F).

Management Notes: Problem fields will require a rotation of several years without onions, garlic, leeks or chives.

FUSARIUM BASAL ROT

Identification: Early symptoms include the yellowing of leaves and tip dieback. As the disease progresses, the whole plant may collapse. The basal plate of the onion becomes pinkish-brown. Secondary bacterial rots may also develop. If the infection occurs late in the season, the symptoms may not show up until the onions are in storage.

Period of Activity: Basal rot occurs under warm soil temperatures. A temperature of 29°C (84°F) is optimum for disease development. Basal rot is not prevalent every year

in all areas. It is often observed on Spanish onions growing in southwestern Ontario.

Management Notes: Crop rotation and the use of disease-free transplants are recommended.

LEEK RUST

Identification: This is an occasional disease of leeks. Rust-coloured spores develop on the upper and lower leaf surfaces. Disease is enhanced on stressed plants.

Period of Activity: Rust occurs during high humidity and low rainfall conditions.

Management Notes: Follow a 2–3-year crop rotation and use only certified seed. Plant into well-drained soils. Separate onion and leek crops.

Bacterial Diseases

SOFT ROT, SLIPPERY SKIN AND SOUR SKIN

Identification: These diseases are characterized by a watery rot and strong smell. Onions with slippery skin may appear sound on the surface. However, the inner rotted portions will slide out through the neck when squeezed. Sour skin first appears as tan or brown rotted leaves followed by a soft rot near the neck.

Period of Activity: Infections begin during wet field conditions. Tissues damaged by onion maggot or other diseases are most prone to infection.

Management Notes: Minimize all types of injury to bulbs (sunscald, bruising and mechanical damage) and provide good storage conditions. Do not put diseased or damaged onions into storage. Avoid using overhead irrigation when the crop is approaching maturity, especially with Spanish types. Harvest onions only when fully mature.

For more information on onion diseases, see the OMAF Factsheet, *Identification of Diseases and Disorders of Onions*, Order No. 95-063.

Insects

CUTWORMS, WIREWORMS

For identification and management information on these common vegetable insects affecting onions, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–44, *Allium Insect Control Recommendations*, on page 118.

ONION THRIPS

Identification: Usually under 2 mm, adult thrips have straw-brown bodies and four wings fringed with hairs. Nymphs are smaller, wingless and pale white in colour. Thrips feeding damage appears as longitudinal, silvery rasping on leaf surfaces. Severe injury may cause reduced yields and increase susceptibility to diseases.

Period of Activity: Thrips favour hot, dry weather conditions. There are usually several generations per year.

Thresholds: The threshold for dry, cooking onions and leeks is 3 thrips per leaf (a lower threshold may be required in areas with insecticide resistance). For Spanish onions, it is 1 thrip per leaf.

Management Notes: Natural controls include a host of predators (such as minute pirate bugs) and some parasites. Heavy rainfall is effective in knocking thrips off the plant for a short time.

Early detection of thrips is key to successful control. See Table 6–44, *Allium Insect Control Recommendations*, on page 118.

ONION MAGGOT

Identification: The onion maggot fly lays eggs around the base of onion plants. Larvae tunnel into the basal plate of the onion causing the plant to wilt and die. Small onion plants are most susceptible to feeding injury. Crop losses of 50%–70% may occur if in-furrow control measures are not used.

Period of Activity: The onion maggot fly overwinters as a pupa in the top 15 cm of the soil. The three generations found in Ontario emerge in early June, July and late August. This pest is present in all onion fields in the Bradford, Keswick and Thedford-Grand Bend areas.

Thresholds: First generation onion maggot thresholds are a combination of trapping and visual scouting. Place four traps (of 3 sticky boards each) centrally along each field edge. Check traps weekly. Assess the percent damage using plots containing 100 onions repeated four times within the field:

Amount of damage	Action
< 2% damage	do not spray
2–5% damage and 5 flies/trap/day	spray
> 5% damage and 2 flies/trap/day	spray

Table 6–44.
Allium Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Onion Maggot						
Soil treatment (in-furrow granular)[2]						
chlorpyrifos[3]	organophosphate	Lorsban 15 G	8–16 kg	3.2–6.4 kg	109	Dry onions only.
					97	Pickling onions only.
		Pyrifos 15 G	8–16 kg	3.2–6.4 kg	109	Dry onions only.
					97	Pickling onions only.
Sprays for onion maggot flies						
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	3	
		Cymbush 250 EC	280 mL	112 mL	3	
diazinon	organophosphate	Diazinon 50 W	1.1 kg	0.44 kg	10	
		Diazinon 500 E	1.1 L	0.44 L	10	
		DZN 600 EW	915 mL	366 mL	10	
naled	organophosphate	Dibrom	550 mL	220 mL	4	
Thrips						
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	112 mL	3	Maximum 3 applications/yr.
naled	organophosphate	Dibrom	550 mL	220 mL	4	
deltamethrin	pyrethroid	Decis 5 EC	200 mL	80 mL	5	Maximum 1 application/yr.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	188 mL	75.2 mL	14	Maximum 3 applications/yr. 24-hr re-entry period.
Cutworms						
chlopyrifos	organophosphate	Lorsban 4E	2.4–4.8 L	0.96–1.92 L	60	Dry onions only.
		Pyrinex 480 EC	2.4–4.8 L	0.96–1.92 L	60	
permethrin	pyrethroid	Pounce	180–390 mL	72–156 mL		Apply up to the 5-leaf stage. Do not disturb soil for 5 days after treating. Use high rate on muck soils.
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	21	Do not disturb soil for 5 days after treating.

[1] DHI = Days to Harvest Interval.
[2] Refer to the label for spacing and planter specifications.
[3] Resistance to these insecticides has been observed in Ontario muck soils.

Management Notes: Apply a granular insecticide at seeding or use treated seed. If these treatments work, first-generation damage may be negligible. Seedlings killed by the first generation are often compensated for with more rapid growth in adjacent onions.

Treatments against adult flies of the first and second generation are not recommended on dry, cooking or Spanish onions. Research in Ontario, New York and Michigan has confirmed that spraying for adult flies does nothing to prevent or reverse onion maggot damage.

LEEK MOTH

The leek moth has been found in several organic garlic fields, in a 40-km (25-mi) radius around the Ottawa/Hull area. The leek moth will attack all *Allium* species. For further information, see the section *Leek Moth*, on page 103, or visit www.omaf.gov.on.ca.

For more information on insect management for onions, see the following OMAF Factsheets and publications:

- *Thrips on Onions and Cabbage*, Order No. 99-027
- *Onion Maggot Control*, Order No. 00-017
- Publication 700, *IPM for Onions, Carrots, Celery and Lettuce in Ontario*

Nematode Control

See the section *Nematodes*, on page 57.

Physiological Disorders

Ozone Injury

This injury begins as small flecks, which can form into whitish spots. These spots can be confused with *Botrytis*; however, they do not have a distinct halo.

Sprout Inhibitor Injury

Maleic hydrazide applied to immature crops can result in spongy bulbs. See the section *Harvest and Storage*, below, for more details.

Sunscald

Sunscald causes severe damage to onions curing in the field. Turn onions during curing to avoid injury. Sunscald injury leads to secondary bacterial infections, which can result in severe crop loss.

Harvest and Storage

Dry Bulb Onions (Cooking, Spanish and Shallots)

Weather and soil conditions often determine the timing of harvest and quality of dry bulb onions. Signs of maturity are soft neck tissues, fallen-over tops and dead roots. Mature onions have better longevity in storage.

The proper use of maleic hydrazide (Royal MH 60) inhibits sprouting and lengthens the storage life of many onion cultivars. Cultivars with a naturally short storage life do not benefit from maleic hyrazide applications.

The optimum time for spraying is when 50% of the tops have fallen, but all tops are still green. This usually occurs 8–14 days before harvest. Plants with less than three green leaves and/or severely diseased foliage will not absorb maleic hydrazide.

Onions are typically cured in the field. In humid areas, artificial curing may be necessary to prevent disease in storage. Storage conditions must be maintained at 0°C (32°F) and 65%–70% relative humidity with good air circulation. Properly stored cooking onions and shallots can be held for 8 months. Spanish onions may last for 2 months in storage.

Bunching (Green) Onions and Leeks

Green bunching onions and leeks are harvested as a whole plant. The roots are trimmed off close to the base of the bulbs and the older, outer scales are removed.

Green bunching onions may be stored for 3–4 weeks, whereas leeks can be stored for 3–6 months. Consistent post-harvest chilling near 0°C (32°F) and careful post-harvest handling will maximize their storage life.

For more information, see the following OMAF Factsheet and publication:

- *Leek Production*, Order No. 91-004
- Publication 487, *Onions*

PARSNIPS

Production Requirements

Parsnips require deep, loose, fertile, sandy loam soils. Well-drained muck soils are also suitable. The desired pH is about 6.5. Parsnips take 100–130 days to mature and should be planted as soon as soil conditions permit.

In Ontario, some parsnips are lifted in late August and sold fresh. Most of the crop is harvested in October and November for winter storage. A portion of the crop may be left in the ground over the winter and harvested in early spring the following year.

Average Yield

Crop	per acre	per hectare
Parsnips	400–500 bushels of graded product	1,000–1,250 bushels of graded product

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Planting, Seeding and Spacing

Optimum germination occurs when soil temperatures reach 10°C–21°C (50°F–70°F). Planting into cool soil conditions may result in reduced stands due to poor germination, low vigour and increased seed decay.

Poor stands also occur if over-worked soil surface becomes baked or crusted before the seedlings emerge. Always use seed produced the preceding year.

Rate:	3–5.5 kg/ha (3-5 lb/ac)
Depth:	6–20 mm (<1 in.) always plant into moisture
Row spacing:	45–75 cm (18–30 in.)
In-row spacing:	3–6 cm (1–2.5 in.) in the row

Fertility

Fertilizer requirements are the same as for carrots. (See the section Table 6–45, *Parsnip Nitrogen Recommendations*, right.) For more details, see the OMAF Factsheet, *Commercial Parsnip Production in Ontario*, Order No. 81-056.

Table 6–45.
Parsnip Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral Soils		
Preplant	70	62
Side-dress	40	36
Total	**110**	**98**
Muck Soils		
Preplant	60	53

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information, see *General Insects and Diseases of Vegetable Crops*, on page 54.

PHOMA CANKER AND LEAF SPOT, ITERSONILIA CANKER

Identification: Both diseases cause brown cankers on the crown and root shoulders. Phoma cankers are often embedded with small, black, fruiting bodies. Phoma- and itersonilia-infected leaves develop small (1-mm) leaf spots with yellow-green halos. Defoliation may occur.

Period of Activity: Phoma canker and leaf spot appear in mid-August. Development is favoured by moderate temperatures, rain and high humidity.

Itersonilia canker requires cool, wet conditions (temperatures around 20°C or 68°F). The fungus overwinters in infected roots and is spread within the field by spores. Itersonilia can also spread through infested seed.

Thresholds: None established.

Management Notes: Phoma canker development may be reduced by harvesting before maximum root and shoulder development. High ridging to cover the shoulder of the roots throughout the season may minimize itersonilia canker infections. Control of the carrot rust fly will help reduce secondary itersonilia infections. Follow a long rotation and bury infected residue. See Table 6–46, *Parsnip Disease and Insect Control Recommendations*, on page 121.

Table 6–46.
Parsnip Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]
Phoma Canker and Leaf Spot					
chlorothalonil	chloronitrile	Bravo 500	2.8 L	1.12 L	7
Carrot Rust Fly					
diazinon	organophosphate	Diazinon 500 E	1.1 L	0.44 L	10
		Diazinon 50 W	1.1 kg	0.44 kg	10
		DZN 600 EW	915 mL	366 mL	10

[1] DHI = Days to Harvest Interval

Insects

CARROT RUST FLY

See the section *Carrot Rust Fly*, on page 76. If monitoring indicates a need, apply as directed in Table 6–46, *Parsnip Disease and Insect Control Recommendations*, above.

Root-Knot Nematode Control

See the section *Nematodes*, on page 57.

Harvest and Storage

Roots may be kept in cold storage for 4–6 months at 0°C (32°F) and 98%–100 % relative humidity. The sweet, nut-like flavour of parsnips develops after the roots have been exposed to temperatures near freezing (late September and October). Mature roots that have not been exposed to low field temperatures may be stored for 2 weeks at 0°C–1°C (32°F–34°F) to develop flavour.

Extremely low temperatures in storage may damage root tissues. Parsnips will freeze at –1.7°C (29°F).

Caution

Some individuals may be sensitive to the natural chemicals found in parsnip foliage. The level of these substances increases if parsnips are diseased. Using rubber gloves when handling parsnip foliage and leg protection when walking in the field will prevent the development of skin rashes.

See also the OMAF Factsheet, *Commercial Parsnip Production in Ontario*, Order No. 81-056.

PEAS

Production Requirements

Peas are a hardy, cool-season vegetable crop. Optimum pea growth occurs at temperatures in the range of 10°C–17°C (50°F–63°F). Crops grown during the warmer part of the summer (temperatures above 24°C or 75°F) will develop overly fiberous pods and starchy seeds. Most pea varieties mature in 50–60 days.

Peas are suited to well-drained soils. Avoid planting early crop into heavy soils or variable fields, as they are more prone to root rots and seed insects. Consider innoculating the seed with rhizoctonia if peas have not been grown in a field in the past five years.

Average Yields

Type	per acre	per hectare
Processing	2–3 tons	4–7 tonnes
Fresh market	150 bu	375 bu

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under Ontario growing conditions. A list of seed suppliers is available in Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding

Seed size varies considerably between varieties. Adjust the planting rate according to both seed size and percent germination. Pea seed requires a minimum soil temperature of 4°C (39°F) for germination. Planting into colder soils will slow early growth, resulting in uneven stand establishment.

Row Spacing: 15–20 cm (6–8 in.)
In-Row Spacing: 4–5 cm (1.5–2 in.)
Rate: 100–300 kg/ha (90–270 lb/ac)
Depth: 2.5–5 cm (1–2 in.). Always plant into moisture.

Fertility

Nitrogen

Where phosphate and potash are required, apply 15 kg N/ha (13 lb N/ac) at seeding. If no phosphate and potash are required, the nitrogen may be omitted.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

If phosphate and potash are required, apply and incorporate them prior to planting. Do not drill fertilizer with the seed.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

These diseases are the most prevalent causes of yield loss in peas. For information on identification and management, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54.

Also see Table 6–47, *Pea Seed Treatments*, below.

Table 6–47.
Pea Seed Treatments

Trade Name	Active Ingredients	Rate/kg seed	Pests Controlled	Notes
Insecticide and Fungicide Combination				
Agrox B-2	diazinon + captan	80 g/25 kg	seed and root maggots, seed decay, damping-off	Use seed within one month of treatment.
Agrox CD	diazinon +captan	50 g/25 kg	seed and root maggots, seed decay, damping-off	Use on seed previously treated with captan or thiram.
Fungicide only				
Apron XL LS	metalaxyl-M	20–40 mL/100 kg	damping-off, root rot	For use in commercial seed treatment plants only.
Captan FL	captan	70 mL/25 kg	seed decay, damping-off, root rot	For use in commercial seed treatment plants only.
Thiram 75 WP	thiram	25–35 g/25 kg	seed decay, damping-off	Do not feed treated clippings to livestock.
Apron FL	metalaxyl	32–110 mL /100 kg	seed decay, damping-off	Do not feed crop to livestock for 4 weeks after planting.
Allegiance FL	metalaxyl	32–110 mL/100 kg	seed decay, damping-off	Do not feed crop to livestock for 4 weeks after planting.
Vitaflo 280	carbathiin + thiram	330 mL/100 kg	seed decay, damping off	Do not feed crop to livestock for 4 weeks after planting.

Table 6–48.
Pea Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aphids						
dimethoate	organophosphate	Cygon 480	275–425 mL	110–170 mL	3	Do not feed or graze vines within 21 days of last application.
		Lagon 480	275–425 mL	110–170 mL	3	
malathion	organophosphate	Malathion 25 W	4.25 kg	1.7 kg	3	
		Malathion 500 E	2.25 L	0.9 L	3	
pirimicarb	carbamate	Pirimor 50 DF	150–275 g	60–110 g	6	
naled	organophosphate	Dibrom	1.1–2.2 L	0.44–0.88 L	4	Processing only.
methomyl	carbamate	Lannate	510 g	204 g	1	24-hr re-entry period.
endosulfan	chlorinated cyclodiene	Thiodan 4EC	1.5–2.0 L	0.6–0.8 L	7	Processing only. Maximum 2 applications/yr.
Slugs						
ferric phosphate	inorganic	Sluggo	25–50 kg	10–20 kg	0	Use higher rates on severe infestations.
Cutworms						
permethrin	pyrethroid	Pounce	180–390 mL	72–156 mL		Apply up to 5-leaf stage. Use high rates on large cutworms. Do not disturb soil for 5 days after treating.

[1] DHI = Days to Harvest Interval.

ASCOCHYTA (MYCOSPHAERELLA) BLIGHT

Identification: Infected seedlings develop symptoms similar to damping-off. The stem tissue above the soil-line turns black, reducing water and nutrient uptake. Plants become stunted and weakened.

Infections on established plants cause brown spots on the leaves and stems. The spots have a distinctive dark border. Infected leaves eventually turn yellow and dry off. Plants remain standing and become straw-like.

Development: This disease complex is transmitted through seed-, soil- and wind-borne spores. Spores travel for long distances and can infect large areas. Humid conditions in the crop canopy promote disease development.

Management Notes: Follow a 4–5-year rotation away from peas and other legume crops. Promote vigorous early-season growth by planting into warm soils and minimizing compaction.

Insects

SEEDCORN MAGGOTS, WIREWORMS, APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting peas, see the section *General Insects and Diseases of Vegetable Crops*, on page 54. Also see Table 6–47, *Pea Seed Treatments*, on page 122, and Table 6–48, *Pea Insect Control Recommendations*, above.

PEPPERS

Production Requirements

Peppers grow well in a wide variety of well-drained mineral soils. Lighter soils produce earlier crops. Peppers perform best at a pH of 6.0–6.8. Cultivars grown in Ontario take from 60–76 days to progress from transplanting to mature green fruit. Add 20–25 days for ripe colour to develop. Full-size green fruit are ready to harvest approximately 30–40 days after pollination.

Average Yields

Type	per acre	per hectare
Processing	10–12 tons	22–27 tonnes
Fresh market	6–8 tons	13–18 tonnes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Plant 200 g of seed to get enough transplants for 1 ha (3oz/ac). For more information, see the section *Vegetable Transplants*, on page 175.

	Row Spacing	In-Row Spacing	Bed Centres
Single rows:			
Early varieties	1.0 m (3 ft)	30 cm (12 in.)	
Standard varieties	1.0 m (3 ft)	45 cm (18 in.)	
Twin rows:	45 cm (18 in.)	45 cm (18 in.)	1.5 m (5 ft)

Plasticulture

Research has demonstrated that the use of plasticulture (plastic mulches, row covers and drip irrigation) can improve the production of fresh market peppers. Use black plastic mulch to control weed growth. For more information, see the section *Plasticulture*, on page 41.

For earlier production of peppers, plant 10–14 days earlier than normal and cover the crop with a white plastic row cover. Open this cover for ventilation when the temperature inside reaches 35°C (95°F) or higher. Remove the cover in early June or whenever conditions are favourable for good growth.

Table 6–49.
Pepper Nitrogen Application Schedule

Method	Actual N per hectare	Actual N per acre
Soil-applied		
Preplant	35 kg	31 lb
Side-dressed	35 kg	31 lb
Total	**70 kg**	**62 lb**
Fertigated		
Preplant	35 kg	31 lb
Transplanting to fruitset	3–5 kg/week	2.7–4.5 lb/week
Fruit sizing	7–10 kg/week	6–9 lb/week
Harvest	3–5 kg/week	2.7–4.5 lb/week

Fertility

Nitrogen

Reduce the nitrogen (N) application if manure is applied or legume sod is plowed down. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Broadcast and incorporate the recommended preplant nitrogen, along with the required phosphate and potash, prior to planting. If it is required, side-dress the remainder of the nitrogen after first fruit set.

For fertigated peppers, broadcast and incorporate the recommended preplant nitrogen, along with all the required phosphate and half the required potash. Apply equal rates of nitrogen and potash through the drip tape according to the schedule in Table 6–49, *Pepper Nitrogen Application Schedule*, above. For more information, see the section *Fertigation*, on page 46.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

If phosphate and potash are required, apply and incorporated them prior to planting. For fertigated peppers, see the section *Nitrogen*, above.

STARTER SOLUTION

At transplanting, apply a high-phosphorus starter solution. Use 1 L of 10-34-0 per 100 L of water or 1 L of 6-24-6 per 75 L of water. Under high temperature conditions or in dry sandy soils, reduce the amount of fertilizer by half but continue to use the same volume of water. This will reduce the risk of crop injury under these growing conditions.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

Sow and transplant in a sterilized soil-less mix. Seed treated with thiram is less susceptible to damping-off and root rots. Use 90 g of Thiram 75 WP per 25 kg of seed.

For more information on identification and management, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54.

BACTERIAL SPOT

Identification: Leaf lesions start as small, water-soaked spots that become large, irregular lesions with pale centres and dark edges. The centre of the spots may drop out, giving leaves a "shot-hole" or ragged appearance. Severely infected leaves may turn yellow and drop. Fruit lesions start as green, circular, slightly raised spots, later becoming brown and scabby.

Development: Bacterial spot prefers temperatures of 24°C–30°C (75°F–86°F). Abundant rainfall and high humidity aid infection.

Thresholds: None established.

Management Notes: Use disease-free or treated seed. Do not plant diseased or unhealthy transplants. Avoid working in fields when foliage is wet. Overhead irrigation may spread this disease. If possible, time irrigation activities early in the day, allowing foliage ample drying time. Some varieties have tolerance to bacterial spot races 1, 2 and 3. Copper fungicides may slow bacterial spot development; see the section *Bacterial Disease Control With Copper Fungicides*, on page 171, for copper use guidelines. See also Table 6–50, *Pepper Disease and Insect Control Recommendations*, on page 126.

VERTICILLIUM WILT

Identification: Verticillium wilt typically begins with the yellowing of older leaves. Infected plants wilt, followed by more severe leaf yellowing and leaf drop. Split the plant stem at the base to check for discolouration of vascular tissue.

Development: Symptoms are often more severe after fruit set or during dry periods. The presence of plant parasitic nematodes may further aggrevate verticillium wilt.

Thresholds: Soil *Verticillium* and root lesion nematode counts, available from the Pest Diagnostic Lab, University of Guelph, will determine the need for control measures. See Appendix H, *Diagnostic Services*, on page 195.

Management Notes: Follow a 4–6-year crop rotation. Do not rotate with related crops, strawberries or raspberries. Keep fields clean of host weeds such as nightshades. Cultivars vary in tolerance to verticillium wilt. Soil fumigation may be required if verticillium and nematode counts are high. See the section *Nematodes*, on page 57.

VIRUSES (CUCUMBER MOSAIC VIRUS, TOMATO SPOTTED WILT VIRUS, ETC)

Identification: Symptoms vary between viruses, cultivars and conditions. Interaction between viruses may occur, complicating visual diagnosis.

Development: Cucumber mosaic is spread by aphids. Tomato spotted wilt is vectored by thrips. The presence of these diseases usually follows periods of high aphid/thrips activity. Tomato mosaic and the streak viruses are spread mechanically.

Management Notes: Control weed hosts in and around the field. Milkweed, ground cherry, pokeweed, chickweed and mother-wort are alternative hosts to the cucumber mosaic virus. See also the section *Aphids*, on page 54.

Insects

CUTWORMS, TARNISHED PLANT BUG, WIREWORMS, APHIDS

For identification and management information on these common vegetable insects affecting peppers, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–50, *Pepper Disease and Insect Control Recommendations*, on page 126.

EUROPEAN CORN BORER

Identification: Larvae are greasy-looking, grey-to-tan-coloured with small brown spots on each segment and a dark head. Full-grown borer larvae reach 2.5 cm (1 in.) in length. Adult moths are light brown with wavy lines across the wings. Larvae usually enter the fruit under the cap, leaving an entry hole with sawdust-like frass.

Period of Activity: Corn borers are present from mid-July through September. The second generation, and sometimes a partial third generation, attacks peppers.

Table 6–50.
Pepper Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Bacterial Leaf Spot						
copper hydroxide	inorganic	Parasol WP	2.25–3.25 kg	0.9–1.3 kg	1	
		Kocide 101	2.25 kg	0.9 kg	1	
copper sulfate	inorganic	Copper 53 W	4 kg	1.6 kg	1	
Fungal Diseases						
pyraclostrobin	strobilurin	Cabrio EG	560–840 g	220–336 g	0	**Anthracnose and early blight control.** Maximum 6 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
boscalid	anilid	Lance WDG	175–315 g	70–126 g	0	**Early blight and grey mould control.** Use 420 g/ha (168 g/ac) for grey mould. Maximum 5 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
Aphids						
pirimicarb	carbamate	Pirimor 50 DF	275–550 g	110–220 g	3	
dimethoate	organophosphate	Cygon 480	0.7–1.0 L	0.28–0.4 L	3	
		Lagon 480	0.7–1.0 L	0.28–0.4 L	3	
diazinon[2]	organophosphate	Diazinon 50 W	0.5–1 kg	0.2–0.4 kg	5	
		DZN 600 EW	460–915 mL	184–366 mL	5	
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–2.25 kg	0.4–0.9 kg	2	
		Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50 W	1.1–2.25 kg	0.44–0.9 kg	2	
acephate	organophosphate	Orthene 75 SP	750 g	300 g	7	Green peach aphid only.
European Corn Borer						
deltamethrin	pyrethroid	Decis 5 EC	250–300 mL	100–120 mL	3	Maximum 3 applications/yr.
permethrin	pyrethroid	Pounce	180 mL	72 mL	1	
carbofuran	carbamate	Furadan 480 F	1.1 L	0.44 L	2	48-hr re-entry period. Maximum 3 applications/yr.
carbaryl	carbamate	Sevin XLR plus	2.5–5.25 L	1.0–2.1 L	2	In areas where corn borer has been a problem, spray every 4 days.
acephate	organophosphate	Orthene 75 SP	1.1 kg	0.44 kg	7	Do not use more than 4 applications/season.
spinosad	naturalyte	Success	83 mL	33 mL	1	Use only on small larvae and low infestations. Maximum 2 applications/yr.
Pepper Maggot						
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1–2.25 kg	0.4–0.9 kg	2	
		Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50 W	1.1–2.25 kg	0.44–0.9 kg	2	
malathion	organophosphate	Malathion 500 E	1.25–2.75 L	0.5–1.1 L	3	
dimethoate	organophosphate	Cygon 480	0.7–1.0 L	0.28–0.4 L	3	
		Lagon 480	0.7–1.0 L	0.28–0.4 L	3	
acephate	organophosphate	Orthene 75 SP	0.75 kg	0.3 kg	7	Maximum 4 applications/yr.
Cutworms						
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.48–0.9 L	40	
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.9 L	40	
permethrin	pyrethroid	Pounce	180–390 mL	72–156 mL	1	Use high rates on large larvae. Do not disturb soil for 5 days after treating.

[1] DHI = Days to Harvest Interval.
[2] Control of aphids with diazinon has been inconsistent in many areas.

Peppers become susceptible to feeding when the fruit are the size of walnuts (3 cm (1¼ in.) in diameter).

Thresholds: There is no tolerance for this pest in processing or fresh market pepper crops. Use pheromone traps to monitor adult flight activity. Scout fields for egg masses and feeding activity.

Management Notes: Protect pepper fruit from fruit set until harvest if corn borers are active in the field. For effective chemical control, distribute spray material thoroughly. See Table 6–50, *Pepper Disease and Insect Control Recommendations*, on page 126.

For more information, consult the OMAF Factsheet, *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019.

PEPPER MAGGOT

Identification: Larvae are legless, whitish-coloured and approximately 11–12 mm (½ in.) long. They do not have a distinct head. The amber-coloured adult flies have yellow and black markings. Females lay eggs in small fruit, creating a small dir. ;e as the fruit sizes. Larvae feed inside the fruit. They are difficult to detect during scouting and grading.

Period of Activity: Pepper maggot activity is confined to the extreme southwest of Ontario and is of concern only in some years.

Thresholds: The presence of adults can be monitored with yellow sticky traps baited with a vial of ammonia. Visual assessments and sweep nets are also used to monitor adult populations.

Management Notes: There is no tolerance for this pest in processing or fresh market peppers. If monitoring indicates a need, apply four sprays at 7-day intervals, starting the last week of June or first week of July. See Table 6–50, *Pepper Disease and Insect Control Recommendations*, on page 126.

Nematode Control

See the section *Nematodes*, on page 57.

Physiological Disorders

Blossom Drop

Pepper flowers or small fruit may abort and fall off due to stressful growing conditions, including:

- daytime temperatures above 30°C–32°C (86°F–90°F) or below 15°C (59°F)
- nighttime temperatures above 21°C (70°F)
- dry weather
- excessive nitrogen
- tarnished plant bug injury
- variety sensitivity

Blossom-End Rot

Blossom-end rot is the result of low soil moisture levels. See the section *Blossom-End Rot (BER)*, on page 173.

Harvest and Storage

Harvest peppers when the fruits are large and firm with a glossy skin. After harvest, wash fresh market peppers in chlorinated water (100–150 ppm chlorine) to eliminate fruit rotting organisms. Green peppers can be held for 2–3 weeks at 7°C–13°C (45°F–55°F) at a relative humidity of 90%–95%. Fully ripe peppers have a shorter storage life.

POTATOES

Production Requirements

Potatoes are adapted to a wide range of soil conditions. The ideal potato soil is a deep, friable, well-drained, sandy loam, free from stones, pH of 6–7, containing adequate organic matter. Such a soil warms up quickly in the spring, holds water well and provides good aeration for the development of tubers. Because potatoes have shallow roots, a minimum of 2.5 cm (1 in.) of water per week is necessary to obtain good yield and quality. Sunny days and temperatures of 18°C–22°C (64°F–72°F) are optimum for vine growth and tuber development.

Cultivars

Table 6–51, *Potato Cultivar Descriptions*, on page 129, outlines the key characteristics of many potato varieties commonly grown in Ontario. Full variety descriptions are available at the Canadian Food Inspection Agency Web site: www.inspection.gc.ca/english/plaveg/potpom/var/indexe.shtml. For information on Ontario variety trials, contact the OMAF potato specialist.

The availability of seed for new or specialty cultivars can often be limited. To ensure a supply of seed, contract with your seed growers. For information on contracting and seed availability lists, contact the Ontario Seed Potato Growers Association at 109 Hutchinson St., Alliston, Ontario, L0M 1A0, fax: (705) 435-5661.

Seed potatoes fall into seed classes, as shown in Table 6–52, *Canadian Seed Potato Classes*, on page 130.

Seeding Rate, Spacing and Depth

The amount of seed needed for planting depends mainly on the spacing within the rows and on the characteristics of the variety. Row spacing is usually set at 90 cm (36 in.) Seed potatoes are planted near ground level and covered with 5–8 cm (2–3 in.) of soil by the planter.

A healthy 55-g (2-oz) seed piece will establish a vigorous plant. Plants from seed pieces smaller than 40 g (1.5 oz) are generally slower to emerge and have less vigour. Small seed pieces are also more likely to decay before the plant becomes established. Seed pieces cut larger than 55 g (2 oz) result in higher seed costs with little additional benefit.

Seed spacing is based on variety characteristics such as tuber set, resistance to hollow heart and resistance to the development of off-shaped tubers. Wider spacing (30–32 cm or 12–13 in.) is recommended for varieties with heavy tuber set, smooth tubers, resistance to hollow heart and low numbers of off-shaped tubers. Closer spacing (20–25 cm or 8–10 in.) is recommended for varieties with lower tuber set to reduce the number of oversized tubers.

Stand Establishment

Several physiological factors influence stand establishment:

Physiological Age of Seed: "Middle-aged" seed emerges faster than young or excessively old seed. The rate of aging depends on cultivar and temperature. Varieties can have short (CalWhite), intermediate (Superior) or long dormancies (Yukon Gold, Jemseg, Eramosa). The rate of aging increases with temperature. Old seed is desirable for the early crop. It emerges faster and more uniformly, sets and bulks tubers earlier and matures faster than plants from young seed.

In long-season areas, the extended bulking period of young seed makes it desirable for the main crop. Old seed may result in lower yields of main crops as plants may be more stress prone.

Apical Dominance: The eye at the apical end of the tuber may inhibit other eyes from sprouting. The delay in emergence from non-apical buds will produce uneven stands when using cut seed from varieties with strong apical dominance such as Jemseg and Yukon Gold. Varieties with weak apical dominance, such as Superior, produce more uniform stands from cut seed.

Eye Distribution: Eye distribution on seed tubers is important. Some varieties have even eye distribution (Superior) while others have eyes concentrated at the apical end. When cut by machine, the latter varieties produce a large proportion of blind seed pieces. Large tubers accentuate the problem and should be graded out and cut by hand.

Check seed coming off the cutter frequently for size, blind pieces and slivers.

Seed Handling and Management

Plant Elite or Foundation Class seed to reduce leaf-roll, mosaic and bacterial diseases. Inspect seed on arrival for heating, freezing, grade and visual signs of tuber disease. Seed lots can be regraded by your local Agriculture Canada seed potato inspector. **Requests for reinspection must be made within two working days of the receipt of the seed potatoes.**

Request at least two certification tags with each bulk load — one for your bin and one for your files.

Table 6–51.
Potato Cultivar Descriptions

Cultivar	Maturity	Tuber Type	Scab Tolerance*	Comments
Tablestock: White Flesh				
Jemseg	very early	smooth, blocky	MR	Tubers oversize quickly. Susceptible to hollow heart. Susceptible to leaf roll and verticillium wilt. Immune to Virus X. Resistant to Virus Y and S.
Eramosa	very early	round-elongated, flattish	MS	Moderately susceptible to Virus Y. Prone to silver scurf in storage.
Envol	very early	smooth	VS	Lower yielding than Superior. Matures about 7 days earlier than Superior.
Superior	early	smooth	T	Susceptible to verticillium wilt and nematodes. Stress substantially reduces yields.
Onaway	early	rough, white skin	MT	Susceptible to blackleg, verticillium wilt, leaf roll and fusarium dry rot.
Cherokee	medium-early	very white skin, medium-deep eyes	T	Good keeper in storage. Misshapen tubers are a problem under adverse weather conditions.
Tablestock: Yellow Flesh				
Adora	early	oblong, light yellow, smooth skin	VS	Low dry matter content. Matures about 1 week later than Superior.
Yukon Gold	mid-season	round to elongated, pink eyes, smooth	VS	Emerges slowly. Use close plant spacings to avoid oversizing and hollow heart. Drought tolerant. Susceptible to air pollution.
Fabula	mid-season	uniform, large, plump, oval	T	Resistant to hollow heart. No culls. Requires low nitrogen.
Tablestock: Cream-Coloured Flesh				
Argos	late	oval, smooth skin, superficial eyes	MT	Tolerates low soil moisture. Do not apply excessive rates of nitrogen.
Tablestock: Red Skin				
Norland	early	smooth, oblong, slightly flattened; shallow eyes	T	Very susceptible to air pollution and moisture stress. Tubers are very susceptible to growth cracks when crop is under sudden stress. Do not use the herbicide metribuzin post emergence.
Chieftain	late	smooth, round; very white flesh	MR	High yielding. Susceptible to heat necrosis, verticillium wilt, blackleg, Virus X and Y. The red skin tends to fade or scurf-over in some soils.
NorDonna	late	round with shallow eyes	MT	Holds colour well in storage. Susceptible to verticillium wilt. Susceptible to most common viruses.
Dual Purpose: Pre-Peel and Tablestock				
Shepody	mid-late	large, oblong, smooth; white flesh	VS	Do not use the herbicide metribuzin post emergence. Susceptible to verticillium wilt. Does not perform well in Southwestern Ontario. Susceptible to Virus Y and S.
CalWhite	mid-late	oblong, large with buff-coloured skin and very white flesh	VS	Very vigorous vine and thick stems. Use close plant spacings to avoid oversizing and hollow heart. Susceptible to leaf roll and net necrosis. Sensitive to metribuzin.
Goldrush	late	smooth golden-russet skin, white flesh	T	Very susceptible to early blight. Very susceptible to most viruses. Resistant to hollow heart.
Kennebec	late	elliptical to oblong; smooth, creamy buff skin; thin skinned	S	Avoid excess nitrogen. Use close plant spacings to avoid oversizing. Tubers are very susceptible to greening. Very susceptible to verticillium wilt and pink eye. Resistant to Virus A and Y.
Gourmet or Specialty Market				
All Blue	mid-late	blue skin and flesh	S	Prone to silver scurf.
German Butterball	mid-late	oval with dark yellow flesh	S	High yield. Excellent flavour.
Banana	late	long, thin fingerling; yellow skin and flesh	S	Good yielder. Excellent flavour.

* VS = Very Susceptible MS = Moderately Susceptible S = Susceptible MT = Moderately Tolerant
T = Tolerant MR = Moderately Resistant R = Resistant

Table 6–52.
Canadian Seed Potato Classes

Class	Field Generation[1]
Nuclear	Greenhouse Laboratory
Pre Elite	1
Elite I	2
Elite II	3
Elite III	4
Elite IV	5
Foundation	6
Certified	7

[1] Seed drops a class each year in the field if it passes inspection.

The tag number gives you direct access to the seed grower. Handle, store and plant the seed carefully. Poor stands and field performance are not always the seed grower's fault.

To help prevent disease, discard all tubers and seed pieces showing signs of rot. Follow good sanitation practices in storage areas and on all knives, containers and handling equipment. For more information, see the section *Storage Sanitation*, on page 49.

Pad all seed-handling equipment as you would harvest equipment. Reduce drops to less than 15 cm (6 in.) to minimize bruising. Ensure that cutter knives are sharp. Cold storage temperatures make seed tubers more sensitive to bruising. Warm seed to at least 5°C–10°C (40°F–50°F) prior to handling. Bruising acts as an entry site for pathogens leading to seed piece decay. Mishandling may physiologically age seed, leading to more stems per plant, smaller tubers and more stress susceptibility.

Cut seed not being planted immediately should be given special attention to ensure healing and suberization by:

- forced-air circulation through the shallow pile
- temperatures of 10°C–15°C (50°F–59°F)
- high relative humidity of 90%–95% (prevent free water from forming on tuber surfaces)

Maintain these conditions for 3–4 days. After this, temperature may be lowered, but humidity must be maintained and fans run intermittently.

Never allow cut seed to stand in the hot sun or in drying wind. This causes minute cracks in the skin that allow bacteria and fungi to establish. Do not plant seed tubers that have been washed.

Table 6–53.
Potato Seed Piece Treatment Recommendations

Common Name	Group	Trade Name	Rate/ 50 kg seed
thiophanate-methyl	benzimadazole	Senator PSPT	250 g
metiram	dithiocarbamate	Polyram 16 D	225–325 g
mancozeb	dithiocarbamate	Tuberseal	250 g
		Potato ST 16	250 g
fludioxonil	phenylpyrrole	Maxim PSP[1]	250 g

[1] On the varieties Shepody and Atlantic, it has been observed that Maxim treatments may increase the number of stems, leading to smaller tuber size.

Seed Piece Treatments

Serious problems with seed piece decay are often related to adverse weather during the planting season. Fungal seed piece decay is usually caused by several species of the fungus *Fusarium*. These pathogens need wounds to enter the seed piece.

There may be little benefit from seed piece treatments if soil conditions are optimal during planting and crop emergence. However, if unfavourable environmental conditions develop soon after planting, treated seed usually produces a better stand. Seed treatments may also help in managing other diseases, including rhizoctonia canker, late blight and blackleg.

Mancozeb, the active ingredient of some *Fusarium* seed treatments, also protects healthy seed pieces against late blight. The late blight fungus can produce spores on cut surfaces of infected tubers in 24 hours. These spores will infect healthy seed pieces. Seed treatments that do not contain mancozeb (MZ), such as Maxim and Senator, do not protect healthy seed against late blight infection. Mancozeb does not cure existing late blight infections; it only prevents new infections.

Gypsum-based coatings act as a drying agent but have no insecticidal or fungicidal activity. Seed treatments are usually dusted onto cut seed as it moves along the conveyor. The seed may then be moved through a rotating drum apparatus to distribute the treatment more evenly. Check the applicator often to be certain that the treatment is being applied at the labelled rate.

See Table 6–53, *Potato Seed Piece Treatment Recommendations*, above.

Do not plant seed lots that are known to be infected with late blight.

Chitting or Green Sprouting

This process may be used for limited plantings, where early emergence and yield are important, or in short-season areas. Chitting is the process of aging seed in the light to control sprout growth, resulting in earlier emergence and sizing. Chitting will take several weeks, so plan well ahead of the expected planting date.

Small, whole seed is placed in shallow containers, 2–3 tubers deep. Air movement and light penetration are essential. Seed can be chitted in a building with fluorescent lights or by natural light in a greenhouse. Short, stubby, dark-green spouts are desirable to minimize sprout damage at planting.

Chitting seed in cool temperatures (such as 8°C or 48°F) under fluorescent light results in shorter sprouts than using warmer temperatures. Seed taken from winter storage of 3°C–4°C (37°F–39°F) will require about 250 degree-days (base 4°C). For the degree day (DD) calculation, see the section *Growing Degree Days*, on page 38.

If the daily maximum temperature is 15°C and the daily minimum temperature is 5°C, using the 4°C base, it would take approximately 41 days (250 DD ÷ 6) to green-sprout the tubers.

Green-sprouted tubers should be planted with cup or bell planters to reduce the chances of green-sprout injury. Avoid pick planters. Sized seed will improve the uniformity of emergence.

If a greenhouse is unavailable, seed can be chitted at 20°C (68°F) in natural shaded light for about 2 weeks with similar results. The same can be accomplished inside a heated building. Higher levels of fluorescent light are required than at cool temperatures. In all cases, provide sufficient humidity to prevent dessication but not enough to stimulate rooting.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

See Table 6–54, *Potato Nitrogen Recommendations*, right. If the total nitrogen-plus-potash applied is over 360 kg/ha (320 lb/ac), broadcast at least a portion before planting to avoid concentrating the fertilizer band near the seed piece and potato roots. Broadcasting or side-dressing nitrogen after potatoes are 20 cm high is not generally recommended, as it may delay maturity.

Table 6–54.
Potato Nitrogen Recommendations

Soil	Actual N		Expected Marketable Yield
	kg/ha	lb/ac	t/ha
Mineral main crop	50	45	15
	75	67	20
	130	116	25
	200	178	30+
Mineral early crop	70	62	
Muck early and main crop	up to 60	53	

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

On mineral soils testing medium or low for phosphate, place some or all of the phosphate fertilizer in bands 2.5 cm (1 in.) below and 6 cm (2½ in.) to each side of the seed piece at planting time. On muck soils or on mineral soils testing high for phosphate, placement is less critical and fertilizer may be broadcast.

Sandy loam soils commonly used in potato production are especially prone to organic matter degradation, wind and water erosion. For tips on how to maintain and improve soil quality, see Chapter 3, *Soil Management*, on page 29.

Petiole Analysis

Samples for plant analysis should be taken, in the morning, at early bloom. Sample at least 50 plants distributed throughout the chosen area. Take the fourth leaf from the tip, including the petiole. Sample problem areas separately. See Table 6–55, *Potato — Interpretation of Plant Analysis*, on page 132.

Plants suspected of nutrient deficiency should be sampled as soon as the problem appears. Expert help will be required to interpret plant-analysis results when the samples are not taken at early bloom. A soil sample should also be taken from the same area. For more information on plant analysis, see the section *Plant Analysis*, on page 14.

Table 6–55.
Potato — Interpretation of Plant Analysis
Values apply to the fourth leaf, including stem, from the growing tip sampled at early bloom.

Nutrient	Units	Critical Concentration[1]	Maximum Normal Concentration[2]
Nitrogen	%	2.50	3.50
Phosphorus	%	0.15	0.50
Potassium	%	1.20	2.50
Calcium	%	1.50	
Magnesium	%	0.10	0.60
Sulphur	%	0.14	
Boron	ppm (ug/g)	2.0	25.0
Copper	ppm	2.0	25.0
Manganese	ppm	15.0	150.0
Zinc	ppm	14.0	70.0

[1] Yield loss due to nutrient deficiency is expected with nutrient concentrations at or below the "critical" concentration.
[2] Maximum normal concentrations are more than adequate but do not necessarily cause toxicities.

Integrated Pest Management

Diseases

Practice a suitable crop rotation to prevent build-up in the soil of organisms causing verticillium wilt, *Rhizoctonia* diseases, common scab and early blight.

SEED-PIECE DECAY

See the section *Seed Handling and Management*, on page 128. ***Note:*** Seed piece treatments will not control bacteria.

FUSARIUM DRY ROT

Symptoms: Sunken or wrinkled areas develop on the surface of tubers. A dark brown-to-black dry decay develops internally.

Development: Bruising or wounding of tubers during harvest or handling favours fusarium dry rot infection. **The leading cause of potato seed piece breakdown after planting is fusarium dry rot.**

Management Notes: A "bag test" is recommended on seed stock after one or two months of storage to assess the fusarium dry rot concentration. Select 20 tubers from the face of the pile, cut them in quarters if small or in eighths if larger and drop them in a new 10-lb potato bag. Shake the bag vigorously for a minute to inoculate the freshly cut seed. Fold the paper bag over loosely, place it inside a plastic garbage bag that is also folded over loosely and place it in your basement, where the temperature will be 16°C–18°C (61°F–64°F). Let the bag sit for 3–4 weeks. If more than 30% of the seed pieces show fusarium dry rot infection, there is a potential high incidence of seed piece decay. See Table 6–53, *Potato Seed Piece Treatment Recommendations*, on page 130.

RHIZOCTONIA

Identification: Typical symptoms of *Rhizoctonia* diseases include stem and stolon cankers, aerial tubers, leaf rolling, premature death of plants and tuber malformations. Black sclerotia (scurf) development on infected tuber surfaces causes serious losses for tablestock growers.

Development: *Rhizoctonia* is a common seed and soil-borne fungus. It is more prevalent during cool, wet springs.

Management Notes: *Rhizoctonia* populations increase in soil where little or no rotation is practised. Avoid land known to be heavily infested with *Rhizoctonia*. Use clean seed, free of black scurf.

EARLY BLIGHT

Identification: Dark brown-to-black spots develop on infected leaves. The spots are often irregular in shape with concentric rings that resemble a target board. Lesions are frequently surrounded by a narrow yellowish border. Symptoms appear first on the older leaves of mature plants, spreading to the younger leaves under favourable weather conditions. Infected tubers develop dark brown-to-black, slightly sunken external lesions.

Development: Temperatures between 17°C–24°C (63°F–75°F) and 12 hours of leaf wetness favour early blight development. Spores are further spread by alternating periods of wet and dry weather. Humidity is needed for spore germination. Dry weather promotes the release of spores and wind dissemination.

Tuber infection occurs at harvest, primarily through cuts, bruises or wounds. Symptoms may appear after the potatoes have been stored for several months.

Management Notes: Begin the fungicide program early and ensure adequate coverage of the lower leaves. Stress conditions such as drought, insect damage, air pollution and rapid growth at tuber sizing increase the plant's susceptibility to early blight. Under these conditions, spray intervals should be shortened to 7 days. Plants infected with *Verticillium* or expressing common mosaic symptoms are particularly susceptible to early blight. See Table 6–56, *Potato — Early and Late Blight Fungicides*, on page 133.

Table 6–56.
Potato — Early and Late Blight Fungicides

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Early Blight	Late Blight	Notes
chlorothalonil	chloronitrile	Bravo 500	1.75–2.25 L	0.7–0.9 L	1	x	x	Use high rate under severe disease pressure. Use higher rates as the crop canopy closes.
mancozeb	dithiocarbamate	Manzate 200 DF	1.1–2.25 kg	0.44–0.9 kg	1	x	x	
		Dithane	1.1–2.25 kg	0.44–0.9 kg	1	x	x	
		Penncozeb 80 WP	1.1–2.25 kg	0.44–0.9 kg	1	x	x	
metiram	dithiocarbamate	Polyram DF	1.1–2.25 kg	0.44–0.9 kg	1	x	x	
azoxystrobin	strobilurin	Quadris	500–800 mL	200–320 mL	1	x	x	Use the high rate for late blight protection. If weather conditions are conducive to late blight, switch to a late blight fungicide. Rotate with a product from a different fungicide family after every application.
pyraclostrobin	strobilurin	Headline EC	450–900 mL	180–360 mL	3	x	x	
boscalid	anilid	Lance WDG	175–315 g	70–126 g	30	x		Do not apply more than 2 applications before rotating to a different fungicide family.
cymoxanil	acetamide	Curzate 60 DF	225 g	90 g	8		x	**Mix with Manzate 200 DF at 1.6 kg/ha.** If seed infection is suspected, spray at 95% crop emergence. 24-hr re-entry period.
propamocarb hydrochloride/ chlorothalonil	carbamate/ chloronitrile	Tattoo C	2.7 L	1.08 L	7		x	Apply prior to infection when weather conditions are conducive to late blight development. Repeat at 7–14-day intervals.
dimethomorph/ mancozeb	morpholine/ dithiocarbamate	Acrobat MZ	2.5 kg	1 kg	14		x	Apply when late blight first threatens or when first visible signs occur nearby. Maximum 3 applications/yr.
zoxamide/ mancozeb	group 22	Gavel 75 DF	1.7–2.25 kg	0.68–0.9 kg	3		x	Begin applications at first sign of late blight or when blight is reported in the area.
fenamidone	group 11	Reason 500 SC	400 mL	160 mL	14		x	Rotate with a product from a different fungicide family after every application.
fenamidone + mancozeb	group 11+ dithiocarbamate	Reason 500 SC + Manzate 200 DF, **or** Dithane, **or** Penncozeb 80 WP	200 mL + 1.25 kg, **or** 1.17 kg, **or** 1.17 kg	80 mL + 0.5 kg, **or** 0.47 kg, **or** 0.47 kg	14		x	
fenamidone + chlorothalonil	group 11 + chloronitrile	Reason 500 SC + Bravo 500	200 mL + 1.25 L	80 mL + 0.5 L	14		x	
copper hydroxide	inorganic	Kocide 101 WP	1.1–2.25 kg	0.44–0.9 kg	1		x	If live spores are suspected at vine killing time, use 3.4 kg/ha of Kocide after top killing in addition to regular foliar sprays.
		Kocide DF	1.1–1.7 kg	0.44–0.68 kg			x	
copper hydroxide	inorganic	Parasol WP	1.1–2.5 kg	0.44–1 kg			x	Combine with 1.75–2.25 kg/ha (0.7–0.9 kg/ac) mancozeb (80%).
copper sulphate	inorganic	Copper 53W	5.5 kg	2.2 kg	1		x	Copper sulphate can cause phytotoxicity, especially under hot and humid conditions. Apply close to vine killing time to kill spores of the late blight fungus.
copper oxychloride	inorganic	Copper spray	4 kg	1.6 kg	1		x	

[1] DHI = Days to Harvest Interval.

LATE BLIGHT

Late blight has the potential to be an extremely destructive disease of potatoes in Ontario.

Identification: Initial symptoms on leaves are small, light-to-dark green, circular-to-irregular shaped, water-soaked spots. Later the lesions become grey-to-tan, surrounded by a light green halo. White and fuzzy mycelium develop at the edge of the lesions, usually on the underside of leaves. Under humid conditions, entire leaves can become blighted as new infections occur and existing lesions coalesce.

Late blight lesions on tubers are irregularly shaped, brown-to-purplish and slightly sunken. The size of the tuber lesions is variable. A reddish-brown, granular dry rot develops under the skin, penetrating less than 1.25 cm (½ in.) into the tuber. Following late blight infection, secondary bacteria infect the tubers, causing a slimy and foul-smelling rot.

The late blight fungus has two mating types, A1 and A2. Only a laboratory analysis can determine which mating type and strain are infecting a crop. Field identification is limited to "late blight." If the two mating types infect the same potato plant tissue and mate, oospores or sexual spores are produced. Oospores are thick walled and survive in the soil for several years in a dormant state. Oospores can initiate soil-borne late blight infections. In Ontario, the presence of oospores in potato fields has not been detected.

Development: The late blight fungus overwinters in infected cull tubers, tubers left in the field after harvest, and in infected seed tubers. The disease develops inside the stems and foliage of plants grown from infected tubers. Temperatures of 12°C–20°C (54°F–68°F), coupled with leaf wetness for a few hours are ideal to initiate sporulation of the fungus on infected plants. Spores are dispersed by wind. They germinate in the presence of free water and penetrate leaves, stems and petioles, initiating new infections. Disease symptoms develop 4–6 days after infection.

Management Notes: Start a preventative fungicide program, before row closure. Keep all foliage and newly formed leaves covered. It is critical to time spray applications so that the crop is protected before infection periods or periods of wet weather occur. See Table 6–56, *Potato — Early and Late Blight Fungicides*, on page 133. Use of the recommended fungicides may also reduce the incidence of tuber blight.

- Plant healthy seed. Tagged seed (Elite or Foundation) gives no guarantee it is not carrying late blight.
- Use a seed treatment containing mancozeb.
- Destroy cull piles (bury, chop, freeze or feed to livestock) prior to new crop emergence. Monitor cull disposal sites and treat emerging sprouts with herbicide.
- Control volunteer potatoes and host weeds growing in neighbouring fields.
- Create a good hill that ensures good tuber coverage.
- Control weeds. Weeds increase the humidity within the potato canopy, favouring the development of late blight.
- If possible, irrigate during the day to avoid prolonged periods of wet foliage at night. Do not irrigate near the end of the season if new outbreaks of late blight are noticed.
- Scout fields twice a week. Pull, bag and remove the first infected plants found. Mark these areas with a flag and recheck.
- Disc in or top-kill any late blight hot-spots immediately.
- Once the disease has been detected in the field, continuous copper sprays kill late blight spores on the soil that might otherwise be washed into the tubers.
- Seal soil cracks to reduce tuber infection.
- Harvest when vines are completely dead so living spores are not sprinkled on tubers at harvest.
- Sort tubers coming into storage. Remove damaged and decayed tubers.
- Monitor the storages frequently. Look for water condensation on the walls and ceiling. Keep the temperature and the humidity at the lowest possible levels to reduce the spread of late blight in storage.

The most effective late blight management program integrates multiple disease management practices and does not rely on a single method.

Potato growers can readily integrate most of the above-mentioned cultural practices to keep tuber blight incidence as low as possible.

Late blight is a community problem. It is easily spread from farm to farm over greater distances. Strategies for control of late blight must be used by all growers.

VERTICILLIUM WILT

Identification: Symptoms are usually noticeable after flowering. Infected stems often wilt during the heat of the day but recover at night. The vascular area or "woody tissue" of infected stems turns brown. As the disease progresses, the foliage turns yellow. The crop dies early,

Table 6–57.
Potato — Pythium Leak, Pink Rot and Fusarium Dry Rot Control

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
In Furrow						
metalaxyl-M	acylamine	Ridomil Gold 480 EC	4 mL per 100 m of row	4 mL per 328 ft of row	80	**Pink rot** Apply directly over the seed pieces in-furrow.
Foliar						
metalaxyl-M/ mancozeb	acylamine/ dithiocarbamate	Ridomil Gold MZ 68WP	2.5 kg	1 kg		Mancozeb, the protectant fungicide in this mixture, should also provide protection against early and late blight. Do not use more than 3 times per season.
metalaxyl-M/ chlorothalonil	acylamine/ chloronitrile	Ridomil Gold/ Bravo Twin Pak	2.21 L (1 jug/4 ha)	0.88 L (1 jug/10 ac)		Do not use more than 3 times per season.
Post Harvest						
mancozeb	dithiocarbamate	Dithane F45	1.58 L per 1,000 kg of seed			Apply to ***seed potatoes only*** prior to storage to control fusarium dry rot.
hydrogen peroxide	inorganic	Oxidate	100 mL per 10 L water			Fusarium dry rot suppression only. Apply prior to storage.

[1] DHI = Days to Harvest Interval.

3–4 weeks before reaching maturity. Tubers do not size and serious yield losses occur. The presence of root lesion nematodes can further aggravate verticillium wilt.

Development: Verticillium wilt persists in the soil for many years. Short crop rotations with susceptible varieties tend to increase the population of *Verticillium* to damaging levels, especially in sandy soils. Verticillium wilt symptoms are increased by crop stress induced by high soil temperatures, drought, nutrient deficiencies and insect damage.

Management Notes: Test soils for *Verticillium* levels. If *Verticillium* and/or nematode levels are high, fumigation may be necessary. Follow a long-term rotation with non-host crops. Plant cereal cover crops after early potatos to control weed hosts, such as nightshade. Good soil management promotes stronger, healthier potato roots.

PYTHIUM LEAK

Identification: Infected tubers develop a cream-to-black watery rot. The rotted flesh is clearly separated from healthy tissue by a dark line. A clear brownish liquid is readily released by the rotted tissue when the tuber is pressed. Pythium leak rot has a sweet smell.

Development: *Pythium* fungi are common to many different crops and soils. Tubers are infected through cut surfaces or bruises that occur at harvest. Pythium leak is particularly troublesome in immature potatoes harvested under warm conditions. Serious losses can also occur when tubers are handled roughly, and when crops are stored at high temperatures with poor ventilation. Pythium leak can also be a problem on cut seed in the field.

Management Notes: Minimize mechanical injury to the tubers during digging, grading and storage operations. Do not harvest when the weather is too hot. Cool tubers immediately after harvest and maintain good air movement in the storage area. See Table 6–57, *Potato — Pythium Leak, Pink Rot and Fusarium Dry Rot Control*, above.

PINK ROT

Identification: Pink rot causes a soft, spongy rot on tubers. On exposure to the air, the infected flesh develops a pink colour and eventually turns completely black. Internal rot usually begins at the stem end and is creamy-coloured or light brown. Wilt symptoms can occur on the foliage.

Development: Infection usually occurs before harvest. This disease is associated with excessive soil moisture, low spots in the field, over-irrigated areas and poorly drained soils. Pink rot may spread slowly in storage.

Management Notes: The varieties Russet Norkotah, Goldrush, Snowden and Kennebec are all very susceptible to pink rot. See Table 6–57, *Potato — Pythium Leak, Pink Rot and Fusarium Dry Rot Control*, above.

BLACKLEG

Identification: Infected seed and sprouts often rot before or soon after emergence, resulting in uneven stands. If the spring weather favours rapid emergence, infected seed will produce weakened, stunted plants. Infected stems show an inky black decay extending up from the infected seed piece. Leaves tend to roll upward at the margins.

Development: The blackleg bacterium is primarily seed-borne. Wet weather and excessive soil moisture favour disease development.

Management Notes: Plant higher generation seed. Poor sanitation and seed cutting practices may increase black leg incidence. Disinfect cutting knives often during seed cutting. Monona and Chieftain varieties are very susceptible to blackleg.

COMMON SCAB

Identification: Round, brown spots develop on the tubers. As tubers increase in size, the lesions expand and scab severity increases. Lesions may be corky and raised, or pitted.

Development: Warm, dry soils during and after tuber-set are conducive to scab development. A soil pH from 6–7.5 is most favorable for common scab. The acid-tolerant scab species (*S. acidiscabies*) can infect tubers in soils with pH as low as 5.

Management Notes: Avoid planting scabby seed. If possible, choose tolerant cultivars such as Superior, Cherokee, Onaway, Norland and Pike. Avoid heavy applications of limestone. Where irrigation is available, maintain high soil moisture for 4 weeks after tuber setting begins. Recent research has shown that application of organic amendments reduces the incidence of scab.

BACTERIAL RING ROT (BRR)

Identification: The type of symptoms expressed by BRR vary depending on the variety. Infected plants may not show symptoms if the weather is cool and wet. The leaflet tissues turn yellow between the veins. Stems and leaves wilt. Infected tubers develop a creamy-brown, cheesy, odourless rot.

Development: Ring rot develops rapidly when soils are dry and temperatures range from 24°C–32°C (75°F–90°F). The ring rot bacterium can survive for up to 2 years as dried slime on cutting knives, storage bins, equipment, bags etc.

Management Notes: Use tagged seed that has had a BRR lab test. Practice complete cleanliness. (See the section *Storage Sanitation*, on page 49.)

Zero tolerance control measures are in place against this disease. The seed potato regulations in Canada indicate that upon a finding of bacterial ring rot, all lots under cultivation by the grower are rejected for certification.

LEAF ROLL AND NET NECROSIS

Identification: Seed-borne infections cause stunted plants with rolled-up lower leaves. Affected leaves are pale and have a leathery texture. Lower leaves eventually die, and upper leaves turn yellow. Yield is reduced in both tuber numbers and tuber size.

Aphid-transmitted infections have similar but less-severe symptoms. In some varieties, notably Russet Burbank and CalWhite, late-season infections may cause net necrosis in daughter tubers, rendering them unmarketable. Shepody is slightly susceptible.

Development: Several species of aphids can transmit the leaf roll virus, but the green peach aphid seems to be the most efficient vector. Infected seed, sprouted cull potatoes and volunteers are the main overwintering sources of leaf roll. Winged aphids spread the virus over long distances.

Management Notes: Control aphids by scouting fields and spraying. Use varieties resistant to net necrosis. Plant tagged seed indicating low or absent levels of this disease.

Physiological Disorders

PINK EYE

For many years, pink eye was thought to be caused by bacteria. However, recent scientific reports suggest that pink eye is a physiological disorder.

Pink eye is characterized by skin-deep, pinkish blotches near the eyes of the stem end. The skin of affected tubers dries and cracks easily. Internal reddish-brown to black discolouration, cavities and secondary soft rots are often associated with severe pink eye. Pink eye occurs sporadically. It usually develops late in the growing season under conditions of high soil moisture.

Management Notes: Increase air flow through the pile to promote drying of pink eye lesions. Pink eye is often associated with *Verticillium* and *Rhizoctonia*. Good control of these fungi will reduce the incidence of pink eye. Varieties such as Kennebec and Superior are very susceptible to pink eye.

BROWN CENTRE AND HOLLOW HEART

Brown centre is associated with cool, wet soil conditions during tuber initiation and/or periods of rapid tuber growth. Pith tissues near the centre of the tuber become light-to-dark brown. The affected cells eventually die.

Hollow heart is common in oversized or rapidly growing tubers. A single large cavity or several smaller cavities develop in the tuber. Cavity size can range from less than 1 cm to a large area that includes the whole pith tissue. This disorder is more severe under conditions that favour rapid tuber enlargement, such as fluctuating soil moisture levels. Wide plant spacings can increase the incidence of hollow heart. The varieties Atlantic and Yukon Gold are very susceptible to hollow heart.

HEAT NECROSIS

Heat necrosis occurs when a period of slow tuber growth is followed by sudden, high temperatures. Tubers develop round or irregular necrotic spots or blotches in the vascular tissue area. Affected tissue ranges from light tan or reddish-brown to rust-coloured. There are no external symptoms of heat necrosis. The varieties Atlantic and Chieftain are very susceptible to heat necrosis.

Insects

WIREWORMS, APHIDS, CUTWORMS, TARNISHED PLANT BUG

For identification and management information on these common vegetable insects affecting potatoes, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–58, *Potato Insect Control Recommendations*, on page 138.

COLORADO POTATO BEETLE

Identification: Bright-yellow eggs are laid in clusters, usually on the underside of leaves. Larvae are orange-red with a distinct black head, humped back and a double row of black dots on each side of their bodies. Adult potato beetles are orange with 10 black stripes on their wings.

Period of Activity: In Ontario, the Colorado potato beetle (CPB) usually completes two generations during the growing season. In warm summers, a third generation may develop.

Adult beetles overwinter in the field or in surrounding, protected areas. First generation and egg-laying occur shortly after emergence. If spring weather is warm, beetle emergence may be very rapid. During cool springs, beetle emergence may be quite slow. Females lay eggs for a 4–5-week period.

Eggs hatch into larvae within 4–9 days, depending on temperature. The larvae pass through 4 stages (instars), reaching maturity in 7–20 days depending on temperature. The pupal stage lasts 5–9 days, after which the next generation of adults emerges. The second-generation beetles feed continuously to accumulate enough energy to survive the winter buried in the soil.

Thresholds: One adult or larvae per plant.

Management Notes: This insect has developed resistance to most of the insecticides registered for its control. See the section *Resistance Management*, on page 53.

To delay the development of resistance in CPB populations, rotate fields so that beetles must walk or fly from overwintering sites to newly planted fields. This takes time, and many beetles die before reaching the new crop. Plastic-lined ditches may be used to trap emerging adults as they walk towards the potato crop from overwintering sites. Propane flamers may also be used on border rows or whole fields until the crop is 15 cm (6 in.) high.

Small CPB larvae are much easier to control than adult beetles or large larvae. See Table 6–59, *Potato — Colorado Potato Beetle Control Recommendations*, on page 139.

Dip tests are recommended before spraying any insecticide because of the high levels of resistance found in CPB populations. Dip tests are very effective in determining which insecticide should provide the best control in your fields.

POTATO LEAFHOPPER

Identification: The adult leafhopper is yellow-green, wedge-shaped and approximately 3 mm long. Immature nymphs are smaller and wingless. When disturbed, leafhoppers quickly move forward or sideways. Both the adults and the nymphs feed on potatoes, causing leaf puckering and browing of the leaf margins (also known as "hopperburn"). Hopperburn is often confused with drought stress.

Period of Activity: Leafhoppers migrate to Ontario in the early spring. Initial generations feed on alfalfa before moving into other crops, such as potatoes.

Thresholds: 0.5 nymphs or adults per plant.

Management Notes: Leafhopper populations can increase rapidly in warm weather. Field scouting is the first line of defence against this insect. Where potatoes are planted in the vicinity of an alfalfa field, scout twice weekly. See Table 6–58, *Potato Insect Control Recommendations*, on page 138.

Table 6–58.
Potato Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aphids						
Soil application						
imidacloprid	chloronicotinyl	Admire 240 F	7.5–12 mL per 100 m of row	7.5–12 mL per 328 ft of row	7	**Will also provide control of leafhoppers and fleabeetles.**
Foliar applications						
methamidophos	organophosphate	Monitor 480	1.75–2.25 L	0.7–0.9 L	14	**Also kills leafhoppers, tarnished plant bugs and flea beetles.** It can be effective against Colorado potato beetle in areas where this insect has not developed resistance to this insecticide yet. 48-hr re-entry period.
dimethoate	organophosphate	Cygon 480	0.55–1.1 L	0.22–0.44 L	7	
		Lagon 480	0.55–1.1 L	0.22–0.44 L	7	
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	21	Green peach and potato aphids only. Maximum 4 applications per season.
pirimicarb	carbamate	Pirimor 50 DF	450–550 g	180–220 g	3	
oxamyl	carbamate	Vydate L	2.3–3.0 L	0.92–1.2 L	7	Green peach and potato aphids only. 24-hr re-entry period.
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	80 mL	7	Maximum 2 applications/yr for all uses. Do not make foliar application after a soil application in the same crop.
pymetrozine	pyridine	Fulfill 50WG[2]	193 g	77.2 g	14	12-hr re-entry period. Maximum 2 applications/yr.[2]
Potato Leafhopper, Flea Beetles, Tarnished Plant Bug						
azinphos-methyl	organophosphate	Guthion 240 SC	2.25–3.5 L	0.9–1.4 L	7	48-hr re-entry period. Maximum 3 applications/yr.
		APM 50 W	1.1–1.75 kg	0.44–0.7 kg	7	
		Sniper 50 W	1.1–1.75 kg	0.44–0.7 kg	7	
dimethoate	organophosphate	Lagon 480	0.55–1.1 L	0.22–0.44 L	7	Not for flea beetle.
		Cygon 480	0.55–1.1 L	0.22–0.44 L	7	
naled	organophosphate	Dibrom	1.1 L	0.44 L	4	Not for tarnished plant bug.
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	21	Maximum 4 applications/yr.
chlorpyrifos	organophosphate	Lorsban 4E	1.0 L	0.4 L	7	Not for leafhopper.
		Pyrinex 480 EC	1.0 L	0.4 L	7	
cypermethrin	pyrethroid	Ripcord 400 EC	62.5–125 mL	25–50 mL	7	Use high rate on tarnished plant bug.
		Cymbush 250 EC	140–200 mL	56–80 mL	7	Maximum 3 applications/yr. Use high rate on tarnished plant bug.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33.2 mL	7	24-hr re-entry period.
deltamethrin	pyrethroid	Decis 5 EC	100–150 mL	40–60 mL	3	Maximum 3 applications/yr.
permethrin	pyrethroid	Pounce	180–260 mL	72–104 mL	1	
oxamyl	carbamate	Vydate L	2.3–3.0 L	0.92–1.2 L	7	24-hr re-entry period.
carbofuran	carbamate	Furadan 480 F	0.55–1.1 L	0.22–0.44 L	7	Use high rate on tarnished plant bug. 48-hr re-entry period. Maximum 2 applications/yr.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–1.5 kg	0.4–0.6 kg	1	Use high rates for tarnished plant bug.
		Thiodan 4 EC	1.5–2.0 L	0.6–0.8 L	1	
		Endosulfan 50W	1.1–1.5 kg	0.44–0.8 kg	1	
Late-Season Cutworms						
chlorpyrifos	organophosphate	Lorsban 4 E	1.2–2.4 L	0.48–0.96 L	7	Apply in early evening for maximum control.
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.96 L	7	
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	7	

[1] DHI = Days to Harvest Interval.
[2] Fulfill 50WG causes cessation of aphid feeding shortly after application. However, aphids may remain on the plant for 2–4 days before they die.

Table 6–59.
Potato — Colorado Potato Beetle Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Soil Treatments						
imidacloprid	chloronicotinyl	Admire 240 F	0.85–1.3 L[2]	0.34–0.52 L[2]		Use 7.5–12 mL per 100 m of row. For best results, spray directly on the seed piece.
phorate	organophosphate	Thimet 15 G	14.5–22.4 kg	5.8–8.96 kg	90	Use the higher rate on heavy silt or clay loam soils. Do not use on muck soils.
Foliar Sprays						
Bacillus thuringiensis	bacterial	Novodor	5.0–8.0 L	2–3.5 L	1	For 1st and early 2nd instar Colorado beetle larvae only; other stages and other insects not controlled. Field scouting is essential for timing the sprays.
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	80 mL	7	Maximum 2 foliar applications/yr. DO NOT use foliar Admire on a field where even part (e.g., border rows) of the field has been treated with in-furrow Admire.
azinphos-methyl	organophosphate	Guthion SC	1.75 L	0.7 L	7	Seven days between applications. Maximum 3 applications/yr. 48-hr re-entry period.
		APM 50W	0.85 kg	0.34 kg	7	
		Sniper 50 W	0.85 kg	0.34 kg	7	
naled	organophosphate	Dibrom	1.1 L	0.44 L	4	
cypermethrin	pyrethroid	Ripcord 400 EC	62.5–125 mL	25–50 mL	7	
		Cymbush 250 EC	140 mL	56 mL	7	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83–125 mL	33.2–50 mL	7	Use the higher rate for larger instars and infestations. Maximum 3 applications/yr at the low rate or 2 applications/yr at the high rate. Do not exceed 250 mL/ha (100 mL/ac) per season. 24-hr re-entry period.
oxamyl	carbamate	Vydate L	2.3–3.0 L	0.92–1.2 L	7	24-hr re-entry period.
endosulfan	chlorinated cyclodiene	Thiodan 50 WP	1.0–1.5 kg	0.4–0.6 kg	1	
		Thiodan 4 EC	1.5–2.0 L	0.6–0.8 L	1	
		Endosulfan 50W	1.1–1.5 kg	0.44–0.6 kg	1	
spinosad	naturalyte	Success 480 SC	166 mL	66.4 mL	7	Will also control European corn borer. Maximum 240 mL of product per year.

[1] DHI = Days to Harvest Interval.
[2] Based on 90-cm (36-in.) row spacing.

Nematode Control

See the section *Nematodes*, on page 57, for control recommendations.

Sprout Inhibition

After completion of a rest (dormancy) period, potatoes sprout readily. Potatoes treated with chemical sprout inhibitors can be stored at 10°C (50°F) or higher without sprouting.

Field-Applied

Maleic hydrazide is a plant-growth regulator, applied as a single application in the field to control sprouting of potatoes in storage. It should be applied in a manner that insures complete and uniform coverage. For example, apply Royal MH 60 SG at a rate of 5.65 kg in 300 L of water/ha (2.26 kg in 120 L water/ac).

Timing is important. Recent research has shown that too early an application on some cultivars may result in phytotoxicity and reduced potato size. Consult manufacturer's recommendations for more detailed information on both rates and timing. Time of application may occur as early as 2–3 weeks past full bloom. Only apply to plants that are green and free from insects, disease and other damage.

Once in storage, tubers treated with maleic hydrazide will not affect seed potatoes stored in the same storage. Crates formerly used for the storage of maleic hydrazide-treated tubers will not affect seed potatoes.

Storage-Applied

CIPC is also widely used for sprout inhibition. Apply it in storage as a dip, spray or aerosol just before sprouting starts. Potato tubers may be treated with this chemical before packaging for market. Do not apply CIPC at harvest time. Application as a gas to storage bins must be performed by a licensed applicator.

To use CIPC in packing lines, prepare 1 L of Sprout Nip EC in 35 L of water, stir to make an emulsion. Use 1 L of this emulsion per tonne of potatoes.

Do not use either of these treatments on potatoes grown for seed. **Do not store seed potatoes in the same storage as CIPC-treated tubers or in crates that were in the storage when CIPC was applied.**

Vine Killing

Vine killing is especially important to seed growers. An early kill controls tuber size and reduces the spread of virus diseases by aphids.

Chemical vine killers are not recommended for early potatoes. They limit the yield, size and dry-matter content without reducing skinning. However, where it is necessary to control size to reduce hollow heart, chemical vine killing may be of value for early potato crops.

Use Reglone (Diquat) as follows:

Heavy green top growth and weeds:	3.5 L/ha (1.4 L/ac)
Medium top growth or crop beginning to mature:	1.7–2.3 L/ha (0.68–0.92 L/ac)
Split application:	1.25–2.3 L/ha (0.5–0.92 L/ac) followed by 1.5 L/ha (0.6 L/ac) in 5–6 days

Apply in at least 550–1,100 L/ha (220–440 L/ac) of clean water. Muddy water may inactivate Reglone. Allow 14–21 days after application until harvest to allow proper vine desiccation and tuber skin set.

Over-application or conditions that lead to very rapid kill may cause darkening at the stem end of the tuber.

Aircraft application of Reglone is not recommended. Ensure that no drift occurs from any of these materials to adjacent crops. The residue of these compounds on other crops may result in their seizure.

The product Ignite (glufosinate ammonium) is labelled as a dessicant on table stock and processing potatoes. **Do not apply to potatoes grown for seed.** Apply 3.0 L in 110–220 L water/ha (1.2 L in 44–88 L water/ac). Use the higher rate of water when the crop canopy is dense. Apply to potato vines 14–21 days prior to harvest. Symptoms of dessication will appear within 2–4 days of applying Ignite.

The product "Des-I-Cate" (endothall) is also labelled. Apply to potato vines 10–14 days prior to harvest. Apply 17–22 L/ha (6.8–8.8 L/ac.) Use the high rate for medium to heavy vine growth and during cool (less than 21°C or 70°F) cloudy weather.

The use of roto-beaters is not recommended except where dead vines or weeds are a hindrance to the digger.

Storage

Store seed tubers separately from tablestock potatoes, in a disinfected storage area. Do not store seed potatoes in the same storage area as CIPC-treated tubers.

Healing of cuts and bruises is most rapid at a tuber temperature of 15°C–21°C (59°F–70°F). It is desirable to provide this temperature for 2–3 weeks at the beginning of the storage period. After this, the temperature should be lowered to 5°C (40°F) if potatoes are intended for tablestock or seed.

Potatoes intended for processing should be maintained at 10°C (50°F) and should never be subjected to temperatures below 5°C (40°F). It will be necessary to use a sprout inhibitor if potatoes are to be stored at 10°C (50°F) for an extended period.

The relative humidity in the storage should be as high as possible without causing condensation of moisture on tubers and the storage structure. However, if soft rot is prevalent, or if the tubers are wet when first put into storage, the humidity should be kept down until the tubers dry. For more information, see the section *Storage*, on page 47.

RADISHES

Production Requirements

Radishes are a cool-season crop. They are adversely affected by hot, dry weather and long days. Roots grown rapidly, with plenty of moisture, are mild, tender and attractive. Slow-growing roots become hot, tough and pithy. Long days (15 hr) and high temperatures result in misshapen roots, long tops and increased seed stalk production. Most radish varieties mature within 30–35 days.

Average Yields

Crop	per acre	per hectare
Radishes with tops	4–7 tons	9–16 tonnes

Cultivars

The most popular cultivars or strains have globe-shaped roots, red skins and leaves that are short-to-medium in length. Medium-top strains are preferable for early spring crops, and short-top strains are preferable during the longer-day period. Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Radish seed may be sown as soon as the soil is workable. Spring frosts or even snowfalls do not seriously injure the crop after the plants have emerged. Under favourable weather conditions, radish seedlings emerge 2 or 3 days after sowing. Sowing at regular intervals in the spring will provide a continuous harvest.

	Row Spacing		In-Row Spacing		Seed Required	
Harvest	cm	in.	cm	in.	kg/ha	lb/ac
Hand harvest	20–30	8–12	2–2.5	1	11–17	10–15
Machine harvest	10–15	4–6	2–2.5	1	22–34	20–30

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

On mineral soils, apply up to 60 kg N/ha (53 lb/ac). On muck soils, apply 40 kg N/ha (36 lb/ac).

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.)

If phosphate and potash are required, apply and incorporate them prior to planting.

Secondary Nutrients and Micronutrients

Boron deficiencies on radish result in the splitting and cracking of the skin. **Calcium** deficiencies cause a backward cupping of leaves and discolouration of the leaf margins. **Magnesium** and **manganese** deficiencies appear as bronzing or yellowing of the leaf tissue between the veins.

See the sections *Calcium*, *Magnesium* and *Boron*, on page 20. Also see Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

OMAF Publication 701, *IPM for Crucifers in Ontario*, contains a section on radish, illustrating many of the common diseases and insect pests.

Diseases

DAMPING-OFF AND ROOT ROTS

Use seed treated with thiram (dithiocarbamate group) seed protectant. Apply 90 g of Thiram 75 WP for every 25 kg of seed. Do not plant seed too deeply and avoid excessive irrigation.

See the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54, for more information.

DOWNY MILDEW

Identification: Symptoms appear as yellow spots on the upper leaf surfaces. Greyish-white fungi may be found on the underside of leaves. Downy mildew infections on the roots cause dark, discoloured areas extending from the crown, down the root. Infected roots may split or become invaded by secondary rot organisms.

Development: Infection can occur at any growth stage. Cool, moist conditions favour disease development. Downy mildew progresses rapidly at temperatures of 10°C–15°C (50°F–59°F). Prolonged periods of leaf wetness, caused by intermittent rain, heavy dews or fog, are also required.

Management Notes: Downy mildew fungi may survive for least 1 year in the soil and 2 years on infected seed. Plant into well-drained soils and follow a 2–3-year rotation with non-crucifer crops. Downy mildew–resistant cultivars are available. Avoid excessive use of overhead irrigation.

FUSARIUM WILT (YELLOWS)

Identification: Infected seedlings rapidly turn yellow and then brown. Infections occuring later in the season cause severely weakened plants with spongy or hollow roots. The vascular tissue of infected roots will be yellowish-brown.

Development: Maximum fusarium wilt growth occurs at soil temperatures of 27°C–29°C (81°F–84°F).

Management Notes: Fusarium wilt is both soil and seed borne. Use certified, treated seed and follow a 2–3-year crop rotation. Resistant cultivars are available. This disease is less common on high pH (alkaline) soils. Maintain a balanced soil pH.

BLACK ROOT

Identification: Infected seedlings die back. Late season infections cause stunted plants and blackening on both the exterior and interior of the radish root. Black root infection usually begins as a dry rot. Secondary bacterial rots eventually cause the disintegration of the root.

Development: This soil-borne disease is favoured by moist, warm soil conditions. Infection occurs between 16°C–32°C (61°F–90°F), with maximum damage occurring at 27°C (81°F).

Management Notes: Plant into well-drained soils and follow a 4-year rotation with unrelated crops. Control all cruciferous weeds. Resistant cultivars are available. Deep-plow infested residue.

SCAB

Identification: Pitted, corky, scale-like spots develop on infected roots. Lesions frequently have raised edges. They may enlarge to 1–2 cm (¼–1 in.) in size.

Development: This soil-borne bacterial disease is favoured by dry soil conditions and high soil pH levels.

Management Notes: Do not grow radish in rotation with potato, carrot or beets. Rotations with grains are partially effective at reducing scab levels in the soil. Maintaining high soil moisture levels with irrigation during root development may reduce infection.

OTHER DISEASES

Radishes may be infected by other diseases, such as clubroot, alternaria leaf spot, white rust and turnip mosaic virus (TuMV).

Insects

APHIDS, CUTWORMS

For identification and management information on these common vegetable insects affecting cole crops, see *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–60, *Radish Insect Control Recommendations*, on page 143.

CABBAGE MAGGOT, CABBAGE LOOPER AND FLEA BEETLES

Several common cole crop insect pests also attack radishes. Cabbage maggot larve feed on radish roots, causing serious economic damage. Flea beetles feed on radish tops, rendering them unmarketable. Cabbage looper and other caterpillars are also an occasional pest of radishes. For identification and management information, see the section *Insects*, on page 86, and Table 6–60, *Radish Insect Control Recommendations*, on page 143.

Harvest and Storage

Radish quality is at its best May, June, September and October. They must be picked frequently. They remain in prime condition for only a few days. Bunched radishes are hand harvested. Topped radishes may be harvested by hand or mechanically.

Remove the field heat from the crop immediately after harvest. Radishes can be stored for 3–4 weeks at 0°C (32°F) and a relative humidity of 95%–100 %.

Table 6–60.
Radish Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cabbage Maggot						
chlorpyrifos	organophosphate	Lorsban 4E	85 mL /1,000 m of row		21	Drench with seed in 380 L water.
		Pyrinex 480 EC	85 mL /1,000 m of row		21	Drench with seed in 380 L water.
Flea Beetles						
permethrin	pyrethroid	Pounce	180 mL	72 mL	2	
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1 L	7	
Aphids						
diazinon	organophosphate	Diazinon 50 W	1.1 kg	0.44 kg	10	Control of aphids with these products has been inconsistent in many areas.
		Diazinon 500 E	1.1 L	0.44 L	10	
		DZN 600 EW	915 mL	366 mL	10	
malathion	organophosphate	Malathion 500 E	1.1–2.75 L	0.44–1.1 L	7	
Cabbage Looper, Imported Cabbage Worm and Diamondback Moth						
spinosad	naturalyte	Success 480 SC	182 mL	73 mL	3	Maximum 3 applications/yr.

[1] DHI = Days to Harvest Interval

RHUBARB

Production Requirements

Rhubarb is a cool-season, perennial vegetable crop. It performs well in deep, well-drained soils. In the spring, growth resumes when soil temperatures reach 7°C (45°F). Temperatures above 26°C (80°F) cause leaf decline and seed stalk development during the months of July and August.

Rhubarb can be grown in the winter as a "forced" crop. Two-year-old crowns are moved inside for the winter. After a dormancy period where temperatures are held below 5°C (40°F) for 7–9 weeks, temperatures of 13°C–18°C (55°F–64°F) will initiate growth. Force rhubarb crowns in the dark, to prevent chlorophyll development. The use of gibberellic acid (Activol GA) is recommended to decrease the required dormancy period. Consult the label for details.

Average Yields

	per acre	per hectare
Fresh market & processing (15–20 stalks per crown)	12–15 tons	27–33 tonnes

Cultivars

A list of rhubarb crown suppliers is available on the OMAF Web site at www.omaf.gov.on.ca. Paper copies are available by calling the Agricultural Information Contact Centre at 1-877-424-1300.

Spacing

Plant in rows 75 cm (30 in.) apart, with plants 75 cm (30 in.) apart in the row. To produce crowns for forcing, spacing in the field may be adjusted to 90 cm (36 in.) between rows and plants without any loss of yield or quality.

Flower Stalk Removal

Flower stalk development reduces plant vigour and depletes valuable resources from the crown. Remove stalks while they are still small and before the flowers open. This can conveniently be done at the same time as harvesting a crop for processing. In crops grown for early fresh market or for forcing, a separate operation will be necessary.

Fertility

Nitrogen

See Table 6–61, *Rhubarb Nitrogen Recommendations*, right, for recommendations.

Table 6–61.
Rhubarb Nitrogen Recommendations

Application Time	Actual N	
	kg/ha	lb/ac
Field-Grown		
Preplanting	100	89
Annually		
Early spring	100	89
After harvest	100	89
Total	**200**	**178**
Crowns for Forcing		
Early spring	100	89
July[1]	180	160
Total	**280**	**249**

[1] As much as 100 kg N/ha (90 lb/ac) of the nitrogen recommendations may be applied through the irrigation system after harvest or in July.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

Integrated Pest Management

Diseases

CROWN ROT AND VIRUS DISEASE

Crown rot infections cause sunken, brown lesions on the base of the stalks. Leaves wilt and die. Infected crowns are very susceptible to secondary bacterial soft rots. The fungi causing crown rot are common to many vegetable crops. Allow for at least 2–3 years between growing vegetables and establishing rhubarb.

Virus diseases cause yellow mottling and spots on the leaves of infected plants. Plants become stunted.

Mark the plants with vigorous growth in June. Use these crowns as planting stock the following spring. Remove and discard all unhealthy crowns.

Insects

APHIDS

For aphid control, apply Assail (acetamiprid) at a rate of 56–86 g/ha (22.4–34.4 g/ac). Maximum 5 applications per year. Maintain a 7-day pre-harvest interval.

For more information on identification and management, see the section *Aphids*, on page 54.

POTATO STEM BORER AND RHUBARB CURCULIO

The stem borer overwinters as eggs on weedy grasses. By mid-summer, the larvae move to larger-stalked plants such as corn, potatoes, tomatoes and rhubarb. Control grassy weeds in and around rhubarb plantings. The rust-coloured rhubarb curculio feeds on stalks, crowns and roots. It overwinters on curl dock. Destroy dock weeds near the rhubarb planting.

Nematode Control

See the section *Nematodes*, on page 57.

Harvest and Storage

Much like asparagus, a limited harvest may occur in the second spring after planting. Remove leaf blades for marketing. Leaves contain oxalic acid and are poisonous to humans.

Store rhubarb at 0°C (32°F) for 2–4 weeks. Maintain a relative humidity (RH) of 95%. Stalks are very susceptible to dehydration.

RUTABAGAS

Production Requirements

Rutabagas can be grown on a wide range of mineral soil types but will perform best on a deep, well-drained loam or sandy loam soil. A frost-hardy crop, rutabagas experience their best growth during cool, fall weather conditions. Rutabagas require about 90 days from planting to harvest.

Average Yields

Crop	per acre	per hectare
Rutabagas	500–600 bu	1,250–1,500 bu

Cultivars

The recommended rutabaga cultivars are the Laurentian strains. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

The optimum soil temperature for germination is from 16°C–29°C (61°F–84°F). There is a very limited market for early rutabaga crops, seeded in April and May. The main crop, grown for winter storage, should be seeded from mid-June to early July. Rutabagas sown during this time can size up during the cool, fall weather, resulting in improved root quality.

Row spacing:	60–90 cm (24–36 in.)
In-Row spacing[1]:	13–15 cm (5–6 in.)
Depth:	1.5 cm (0.5 in.)
Rate:	approx. 500 g of seed/ha (7oz/ac)

[1] Precision-seed or thin plants to the recommended in-row spacing.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

Apply up to 35 kg N/ha (31 lb/ac). Manure may be used in the rotation at the rate of 18–22 t/ha (8–10 tons/ac) but should be applied at least a year before the rutabaga crop is grown.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

If phosphate and potash are required, they should be applied and incorporated prior to planting.

Secondary and Micronutrients

BORON

Water-core or brown heart, caused by boron deficiency, first appears in young, enlarging roots as firm, brownish, water-soaked patches. Severely affected rutabagas may turn punky inside during storage.

The necessary quantity of boron can be mixed with preplant fertilizer applications. Apply boron-enriched fertilizer as uniformly as possible. Foliar applications of Solubor are often as effective as larger amounts applied to the soil. Make the first foliar application when the roots are about 1.5–2.5 cm (⅔–1 in.) in diameter. The second and third applications may be applied at 10- to 14-day intervals.

Do not combine pesticides with boron sprays unless the label specifies compatibility. Excessive applications of boron will often adversely affect next year's crop (e.g., beans and small grains). See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

OMAF Publication 701, *IPM for Crucifers in Ontario*, provides a good summary of IPM for rutabagas in Ontario.

Diseases

DAMPING-OFF AND ROOT ROTS

Seed treated with thiram (dithiocarbamate group) will help prevent damping-off, seedling blight and seed decay. Use 90 g of Thiram 75 WP for every 25 kg of seed. See the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54, for more information.

Table 6–62.
Rutabaga Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Mosaic Virus						
mineral oil	N/A	Superior Oil 70	10 L in 550–1,100 L water	4 L in 220–440 L water	21	Do not apply mineral oil in direct sunlight. Aphid feeding deterrent only.
Powdery Mildew						
propiconazole	triazole	Topas 250 E	400 mL in minimum 200 L of water	160 mL in minimum 80 L of water	21	A second application may be made 20 days after the first.
sulphur	inorganic	Microscopic Sulphur[2]	6.8 kg in 675–1,125 L of water	2.75 kg in 270–455 L water	0	Maximum 5 applications/yr.
pyraclostrobin	strobilurin	Cabrio EG	560–840 g	224–336 g	3	3-day re-entry period. Maximum 3 applications/yr. Do not use more than 2 applications before rotating to a different fungicide group.

[1] DHI = Days to Harvest Interval.
[2] This product is not compatible with Superior Oil.

BLACK ROT AND BLACK LEG

Identification: Seedlings infected with black rot usually die. Later infections cause stunted plants with yellowing, wilting foliage. Leaf and stem veins and the vascular bundles under the skin of the root turn black. Root rots may also develop.

Seedlings infected with black leg may die or may simply lose their cotyledons. On mature plants, cankers develop on the root. Dry, sunken spots with dark borders develop in storage. Waxed roots rot rapidly.

Development: Rutabagas are susceptible to these diseases at the seedling stage, as mature plants and in storage.

Management Notes: Do not apply manure containing rutabaga refuse or diseased rutabagas on land intended for rutabagas. Follow a 4–5-year rotation away from all cruciferous crops. The blackleg pathogen can move with wind and water from adjacent fields. Control cruciferous weeds. Never store diseased rutabagas. Clean out and disinfect the storage area each spring. See the section *Storage Sanitation*, on page 49.

CLUBROOT

Identification: Galls develop on the taproot or secondary roots. Infected plants become stunted. Older leaves may yellow and drop. Younger leaves wilt during the heat of the day.

Development: The clubroot pathogen prefers temperatures of 19.5°C–23°C (67°F–73°F) and high soil moisture levels. This disease tends to be more severe on acid soils.

Management Notes: Clubroot is the most serious disease affecting rutabagas. Use a long crop rotation (at least 5 years) with non-cruciferous crops to avoid infection. Avoid fields known to be infested. Maintain a soil pH of 7.2.

POWDERY MILDEW

Identification: White, powdery spots develop on the upper surface of older leaves. Leaves turn pale green to yellow and eventually die.

Development: Powdery mildew prefers periods of hot weather and low humidity. It requires some moisture (from heavy dews or intermittent rain) for initial infection.

Management Notes: The cultivar Laurentian is very susceptible to powdery mildew. Fungal spores are carried long distances by wind. Control must be initiated at the first appearance of symptoms. See Table 6–62, *Rutabaga Disease Control Recommendations*, above.

TURNIP MOSAIC VIRUS (TUMV)

Identification: Older leaves turn yellow and drop prematurely. Leaves emerging after infection are stunted and wrinkled and show a yellow mottled pattern. Roots become "goosenecked" and do not reach normal size.

Development: TuMV is spread by aphids. A rapid increase in infection usually begins in early July, when

large numbers of winged aphids become active. Volunteer rutabagas and winter canola are the main overwintering sources of the virus.

Management Notes: Losses from turnip mosaic virus are especially heavy in plantings sown after mid-June. Applications of mineral oil (Superior 70 Oil) deter the feeding of virus-spreading aphids. See Table 6–62, *Rutabaga Disease Control Recommendations*, on page 147. Aphid control does not completely prevent the spread of the virus.

For more information, see the OMAF Factsheet, *Turnip Mosaic Virus (TuMV) of Rutabaga*, Order No. 88-091.

Insects

CUTWORMS, APHIDS

For identification and management information on these common vegetable insects affecting rutabagas, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–63, *Rutabaga Insect Control Recommendations*, on page 149.

CABBAGE MAGGOT

Identification: The white, legless maggots feed and burrow in the roots, rendering them unmarketable.

Period of Activity: Cabbage maggots overwinter as pupae in the soil. There are three periods of maggot damage related to the emergence of the three generations of flies — early in the season (prior to mid-June), during early July and late in the season (after mid-August).

Thresholds: Monitoring programs for cabbage maggot adults may help with spray timing.

Management Notes: Follow a 3–4-year crop rotation. Do not grow early and late rutabagas in the same field or near winter canola, early broccoli, cabbage or cauliflower. Control of root maggots can be timed to coincide with the start of the egg-laying activity of each generation of adults. See Table 6–63, *Rutabaga Insect Control Recommendations*, on page 149.

FLEA BEETLES

Identification: Small, shiny, black beetles feed on leaves and cotyledons, leaving a "shot-hole" appearance. They may also feed on the stem below the soil surface. Larvae feed on the roots.

Period of Activity: Rutabagas are most vulnerable at the seedling stage. Larval feeding on the root may reduce marketability.

Thresholds: None established.

Management Notes: Target controls at the adult beetle stage. There is no control for larvae established in roots. Insecticide should be applied as soon as the beetles appear in the field. Beetles may migrate into the field over several weeks, resulting in the need for multiple applications. If insecticide drenches are used to control root maggots, flea beetles may also be controlled.

See Table 6–63, *Rutabaga Insect Control Recommendations*, on page 149. To limit the development of resistance, alternate between insecticide groups.

LEAF-EATING CATERPILLARS

Cabbage worm, diamondback moth and cabbage loopers may attack rutabagas. For more information, see the section *Imported Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar*, on page 88. Also see Table 6–63, *Rutabaga Insect Control Recommendations*, on page 149.

Before feeding rutabaga tops or trimmings to livestock, check all pesticide labels for restrictions.

Nematode Control

See the section *Nematodes*, on page 57, for control recommendations.

Harvest and Storage

Damaged and bruised rutabagas are likely to rot and do not store well. To reduce losses from post-harvest diseases, change the water in the wash tank frequently or add fresh water continuously to keep water as clean as possible. Rinse rutabagas with clean water and dry immediately. Trimming after washing also helps reduce storage rots. Calcium hypochlorite in the rinse water has shown to be effective in reducing losses after waxing. See the section *Storage Sanitation*, on page 49.

Waxing

Rutabagas are normally hot-waxed just before being marketed. Waxing improves their appearance, keeps them clean, protects freshly trimmed surfaces from disease organisms and prevents undue moisture loss and shrinkage during the marketing period. Waxing is not recommended for rutabagas being held in storage.

Table 6–63.
Rutabaga Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cabbage Root Maggot						
Treatment at Planting						
chlorpyrifos	organophosphate	Lorsban 15 G	0.6–1 kg per 1,000 m of row	0.18–0.3 kg per 1,000 ft of row		
Treatment After Planting						
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/ 1,000 m of row (in 125 L of water)	64 mL per 1,000 ft of row (in 125 L of water)	28	Apply on soil, 10 cm (4 in.) on each side of the plant, 10 days after seeding.
Subsequent Treatment						
chlorpyrifos	organophosphate	Lorsban 4E	210 mL per 1,000 m of row	64 mL per 1,000 ft of row	28	Apply on soil, 10 cm (4 in.) on each side of plants, 28, 49 and 70 days after seeding. Maximum 4 applications/ season.
Flea Beetles						
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1.0 L	7	
permethrin	pyrethroid	Pounce	180 mL	72 mL		Apply before 8-leaf stage.
cypermethrin	pyrethroid	Cymbush 250 EC	200 mL	80 mL	21	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	0.8 L	45	Use no more than 2 applications/ season.
		Thionex EC	2.0 L	0.8 L	45	
Aphids						
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	0.8 L	45	Use no more than 2 applications/ season.
		Thionex EC	2 L	0.8 L	45	
Leaf-Eating Caterpillars						
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2.0 L	0.8 L	45	Use no more than 2 applications/ season.
		Thionex EC	2 L	0.8 L	45	
spinosad	naturalyte	Success 480 SC	182 mL	73 mL	3	Maximum 3 applications/yr.
Cutworms						
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.5–1.0 L	30	May be used at the rate of 2.4 L/ha (1.0 L/ac) as a preplanting treatment. Apply once at seedling stage (2–5 leaves), when damage first appears.
		Pyrinex 480 EC	1.2–2.4 L	0.5–1.0 L	30	

[1] Days to Harvest Interval.

Immerse clean, dry rutabagas for one second in a "rutabaga/turnip" wax at 126°C (259°F) and then pack as desired for market. Temperatures must be kept low after waxing. Waxed rutabagas can spoil within a few days at room temperature. Rutabaga wax is available from International Group Incorporated (IGI), 50 Salome Dr., Agincourt, Ontario, tel. (416) 293-4151. Ask for "turnip wax" — product code 2291.

Storage

Disease-free rutabagas will keep up to 6 months. Store at 0°C (32°F) and a relative humidity of 90%–95%. Maintain adequate ventilation and air movement throughout the storage area. Clean the storage area thoroughly between crops. See Table 4–15, *Proven Disinfectants*, on page 50.

SPECIALTY VEGETABLES

Many of the specialty vegetables grown in Ontario are of Asian and Middle Eastern origin. These crops belong to a range of plant families including legumes, cole crops, cucurbits and others. Pest management strategies developed for more traditional crops in Ontario may be helpful in these crops, since they often have a similar insect and disease complex.

Nomenclature

Many of the crops of Asian origin have different names in different languages (Mandarin Chinese, Cantonese Chinese, Vietnamese, Korean or Japanese, for example). Table 6–64, *Specialty Vegetables*, on page 151, summarizes some of the Asian specialty vegetable crops grown in Ontario.

For more information, see the OMAF Factsheets *Asian Vegetables Grown in Ontario*, Order No. 98-033, and *Chinese Cabbage Production in Southern Ontario*, Order No. 86-090.

Fertility

Because of the wide range of specialty crops, a single fertility recommendation cannot be made. However, a balanced fertility program based on a soil test can form the basis for good crop health. Experience from traditional, related crops will also be useful. See the section *Fertilizer Recommendations*, on page 17, for more information on nitrogen, phosphorous, potassium and the micronutrients.

Integrated Pest Management

OMAF Publication 701, *IPM for Crucifers in Ontario*, provides a comprehensive reference for many of the insects and diseases affecting specialty vegetables.

Diseases

Many of the diseases affecting these crops may be seedborne. Ensure, where possible, that the seed is certified as disease-free or within acceptable guidelines. Hot water seed treatments may also be helpful. (See the section *Hot-Water Treatment*, on page 179.)

The following best management practices can help reduce disease problems:

- use treated seed
- deep-plow crop residues into the soil
- eliminate cull piles
- rotate crops annually
- remove weed hosts
- reduce overhead irrigation
- use only healthy transplants grown in clean plug trays and sanitized greenhouses

For chemical control options, see Table 6–65, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 153.

COMMON DISEASES OF SPECIALTY VEGETABLES

Asian radish (lo bok, daikon, moo): Turnip mosaic virus, downy mildew, alternaria leaf blight

Nappa cabbage (siew choy, da bai cai, baechu): Turnip mosaic virus, downy mildew, soft rot, alternaria leaf spot, clubroot, pseudocercosporella leaf spot

Bok choy, gai choy, yow choy, pak choy, gai lan, etc.: Turnip mosaic virus, downy mildew, soft rot, clubroot, pseudocercosporella leaf spot, alternaria leaf blight

Cucurbits (fuzzy squash, bitter melon, winter melon): Powdery mildew, mosaic viruses, bacterial wilt, angular leaf spot, scab, anthracnose

DOWNY MILDEW

Identification: Symptoms appear as yellow spots on the upper leaf surfaces. Greyish-white fungal growths often develop on the undersides.

Development: Infection can occur at any growth stage. Cool temperatures of 10°C–15°C (50°F–59°F) and prolonged periods of leaf wetness, dew or fog support rapid downy mildew development. This fungus overwinters in seed and on infected plants. Downy mildew fungi survive for at least 1 year in the soil and 2 years in infected seed.

Thresholds: None established.

Management Notes: Plant into well-drained soil conditions. Avoid excessive use of overhead irrigation. Practice a 2-year rotation with non-crucifers. For bok choy, if weather conditions favour disease development, apply one of the preventative fungicides listed in Table 6–65, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 153.

Table 6–64. Specialty Vegetables

English	Chinese[1]	Korean	Japanese	Vietnamese	Latin
Edible amaranth (callaloo, tampala)	hinn choy (C), xian cai (M)	chambirum	hi yu na	rau den do	*Amaranth mangostanus* *A. gangeticus*
Asian water celery or Water dropwort	shui qin (M)	minari	seri	cang nuoc, rau can nuoc	*Oenanthe stolonifera*
Asparagus bean or Snake bean	dau guak (C), cai dow (M)	gin kong	sasage	dua-dua	*Vigna unguiculato* var. *sesquipedalis*
Bitter melon	ku gua (M), fu gua (C)	ssunoi	ni ga uri	muop dang, khoqua	*Momordica charantia*
Bitter melon leaves	fu gua yip			la khoquo	*Momordica charantia*
Burdock root	ngao pong (C)	uang	gobo		*Arctium lappa*
Chinese broccoli or Chinese kale	gai lan (C), jie lan (M)		kailaan	cai ro	*Brassica alboglabra*
Nappa cabbage or Chinese cabbage	siew choy (C), won bok (C), da bai cai (M), huan ya bai (M)	baechu	hakusai	cai bac thao, cai dai	*Brassica rapa* var. *pekinensis* group
Chinese chives	gow choy (C), jiu cai (M)	buchu	nira	he	*Allium tuberosum*
Chinese cucumber	wong gua (C), huang gua (M)	oi		dua leo	*Cucumis sativus* var. *sativus*
Big leaf mustard	dai gai choy (C), da jie cai (M)	gat	karashina	cai zanh	*Brassica juncea* var. *involutus*; var. *foliosa*
Chinese okra or Sponge gourd	guang dong si gua, si gua		shokuyou hechima, hechima	muop khia, muop huong	*Luffa acutang'ula*, *Luffa aegypitaca*
Chinese squash/ pumpkin	nam gua (C), nan gua (M)	ho bak	kabocha	bi ro	*Cucurbita moschata*
Japanese pumpkin	yin du nan gua		seiyou-kabocha	bi	*Cucurbita maxima*
Chrysanthemum greens	tong hao cai (M), tong ho choy (C)	ssukgat	shungiku	tan o, cai cui	*Chrysanthemum coronarium*
Flowering edible rape	yow choy (C), you cai (M)	yuchaeip	aburana	cai ngot	*Brassica rapa* var. *oleifera*
Fuzzy squash	mao gua, jie gua (M), tsit gua (C)	ho bak	tohgan	bi chanh	*Benincasa hispida* var. *chieh-qua*
Edible mallow (melokhia)				rau day	*Corchorus olitorius*
Red/green mustards	gai choy (C), jie cai (M)	gat	karashina	cai xanh	*Brassica juncea* var. *rugosa*; var. *crispifolia*
Malabar spinach	lo kwai (C), san choy (C), zi luo kui (M), lu luo (M)		tsuru-murasaki	mong to'i	*Basella alba*, *Basella rubra*
Flowering Chinese leaf cabbage	choy sum (C), cai xin (M)		saishin	cai ngot non	*Brassica rapa* var. *parachinensis*
Flat flowering Chinese leaf cabbage	nai yow choy (C)				*Brassica rapa* var. *narinosa*
Rosette Chinese leaf cabbage	tak choy (C), wu ta cai (M)		tatsoi	cai tua xai	*Brassica rapa* var. *rosularis*
Purple mint, beefsteak plant	zi su (C)	dulketip	shiso	tia to	*Perilla frutescens*, *Perilla crispa*
Asian radish	lo bok (C), luo bu (M)	moo	daikon	cu-cai	*Raphanus sativum* *Longipinnatus* group
Potherb mustard	shui cai (C)		kyona, mizuna		*Brassica juncea* var. *japonica*
Salad rocket (arugula)					*Eruca vesicaria*
Snow peas	ho lan dow	wando	saya endo		*Pisum sativum* var. *macrocarpon*
Snow pea shoots	dow miu (C), dou miao (M)	wandusun	tohbyo		*Pisum sativum* var. *macrocarpon*
Thick petiole white Chinese leaf cabbage	bai cai (M), bok choy (C)	bok choy	shakushina	cai thuong hai	*Brassica rapa* var. *chinensis*
Thin petiole white Chinese leaf cabbage	pak choy (C), xiao bai cai (M)	pak choy	shakushina, chingensai (green stem)	cai trang laon	*Brassica campestris rapa* var. *chinensis*
Water spinach	tung choy (C), kongxin cai (M)	kongshim-chae	kankon, asagaona, ensai	rau muong	*Ipomoea aquatica*
Winter melon	tung kwa (C), don gua (M)		tohgan	bao	*Benincasa hispida*

[1] C = Cantonese Chinese, M = Mandarin Chinese

WHITE LEAF SPOT

Identification: Infected leaves exhibit scattered, circular, white-to-tan spots contained by leaf veins. These spots become white and papery, enlarging as the disease develops. Heavily infected plants may show severe spotting, with some defoliation. On waxy-leafed crucifer species, the lesions take on a branching shape.

Development: White spot persists from season to season on leaf litter. Cool temperatures from 12°C–18°C (54°F–64°F), rainfall and long periods of humidity are conducive to disease development. Spores can be spread by wind, splashing rain and irrigation. The disease does not spread in warm weather.

Management Notes: Follow the best management practices for disease control listed in the section *Integrated Pest Management*, on page 150.

Insects

CUTWORMS, APHIDS, TARNISHED PLANT BUG

For identification and management information on these common vegetable insects, see *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–65, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 153.

COMMON INSECTS OF SPECIALTY VEGETABLES

Cabbage looper, diamondback moth, imported cabbage worm and cabbage maggots attack many specialty vegetables. Full pest management information for these pests may be found in the section *Imported Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar*, on page 88. See Table 6–65, *Specialty Vegetables Disease and Insect Control Recommendations*, on page 153.

PEA LEAF MINER

The pea leaf miner causes severe stipling (bronzing) on the leaves of Asian crucifers and other leafy greens. Mining damage from larvae is not common in the specialty crops. See the section *Leaf Miners*, on page 80, or the OMAF Factsheet, *Leaf Miners Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039.

Harvest and Storage

Most specialty vegetables reach maturity in 40–70 days (sometimes 90–100 days for late fall nappa cabbage) under good growing conditions. All specialty vegetables are hand-harvested. Most radish and melon types are washed before marketing. The leafy greens are packed directly into crates or boxes in the field.

Leafy greens are a very perishable product. If they are cooled immediately after harvest, and topped with ice, they can be stored for 10–14 days. Optimal storage conditions are 0°C (32°F) and a relative humidity of 95%–100%.

Table 6–65. Specialty Vegetables Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Downey Mildew						
fosetyl-al	phosphonate	Aliette WDG	2.25–3.12 kg	0.9–1.25 kg	7	**Bok choy only.** Maximum 5 applications/yr. 12-hr re-entry period.
Aphids						
dimethoate	organophosphate	Cygon 480	0.6–1.0 L	0.24–0.4 L	7	**Chinese broccoli, Chinese cabbage, pak choy.**
		Lagon 480	0.6–1.0 L	0.24–0.4 L	7	Maximum 3 applications/yr.
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	**Mustard greens.** Maximum 3 applications/yr.
acetamiprid	chloronicotinyl	Assail 70 WP	56–86 g	22.3–34.4 g	7	**Mustard greens, amaranth, chrysanthemum greens, kale, kohlrabi, Chinese cabbage, bok choy.** Maximum 5 applications/yr. Alternate applications with other insecticide groups.
Swede Midge						
acetamiprid	chloronicotinyl	Assail 70 WP	86 g	34.4 g	7	**Broccoli raab, Chinese cabbage (nappa), bok choy, chinese mustards, kale, kohlrabi, mustard greens, rape greens.** Maximum 5 applications/yr. Alternate applications with other insecticide groups.
Cutworms						
chlorpyrifos	organophosphate	Lorsban 4E	2.4 L	0.96 L	32	**Chinese cabbage:** Preplant.
			1.2–2.4 L	0.48–0.96 L	32	**Chinese cabbage:** Seedlings.
		Pyrinex 480 EC	2.4 L	0.96 L	32	**Chinese cabbage:** Preplant.
			1.2–2.4 L	0.48–0.96 L	32	**Chinese cabbage:** Seedlings.
Flea Beetles						
carbaryl	carbamate	Sevin XLR plus	1.25–2.5 L	0.5–1 L	21	**Chinese cabbage, mustard greens.**
Tarnished Plant Bug						
carbaryl	carbamate	Sevin XLR plus	2.5–5.25 L	1–2.1 L	21	**Chinese cabbage, mustard greens.**
Cabbage Maggot						
azinphos-methyl	organophosphate	Guthion Solupak	1 kg in 1,000 L water	0.4 kg in 400 L water	21	**Chinese cabbage.** Apply 115–170 mL per plant at or immediately after transplanting.
chlorpyrifos	organophosphate	Lorsban 4E	210 mL/ 1,000 m of row	64 mL/ 1,000 ft of row	15	**Chinese cabbage, pak choy only.** Apply 7–10 days after seeding or 3 days after transplanting. Repeat 21 days after transplant drench or 28 days after seeding.
			150 mL/ 1,000 m of row	45 mL/ 1,000 ft of row	21	**Chinese broccoli (gai lan, kailaan).** Apply 5–7 days after seeding.
			210 mL/ 1,000 m of row	64 mL/ 1,000 ft of row	32	**Asian-type radish (lo bok, daikon, moo).** Apply 7, 20 and 35 days after seeding.
		Pyrinex 480 EC	150 mL/ 1,000 m of row	45 mL/ 1,000 ft of row	21	**Chinese broccoli (gai lan, kailaan).** Apply 5–7 days after seeding.
			210 mL/ 1,000 m of row	64 mL/ 1,000 ft of row	32	**Asian-type radish (lo bok, daikon, moo).** Apply 7, 20 and 35 days after seeding.
Cabbage Looper, Diamondback Moth and Imported Cabbageworm						
Bacillus thuringiensis	microbial	Dipel 2XDF[2]	275–550 g	110–220 g	0	**Mustard greens.**
			55–550 g	22–220 g	0	**Chinese cabbage, Chinese broccoli, bok choy, Asian radish.**
		Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	**Mustard greens.**
carbaryl	carbamate	Sevin XLR plus	2.5–5.25 L	1–2.1 L	21	**Chinese cabbage, mustard greens.**
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	**Mustard greens** (looper only).
permethrin	pyrethroid	Pounce	90–180 mL	36–72 mL	3	**Pak choy, Chinese cabbage.** Maximum 4 applications/yr.
					7	**Chinese broccoli.** Maximum 4 applications /yr.
azinphos-methyl	organophosphate	Guthion Solupak	1.12–1.75 kg	0.45–0.7 kg	21	**Chinese cabbage.** Maximum 3 applications /yr.
spinosad	naturalyte	Success 480 SC	182 mL	73 mL	1	**Chinese celery.** Maximum 3 applications/yr.
					3	**Oriental radish.** Maximum 3 applications/yr.

[1] DHI = Days to Harvest Interval.
[2] Rates vary depending on the pest: diamondback moth = 275 mL/ha, cabbage looper = 275–550 mL/ha, imported cabbageworm = 55–140 mL/ha.

SPINACH & SWISS CHARD

Production Requirements

Spinach production occurs mainly in the spring or the fall. Under long days and warm-weather conditions, plants quickly bolt (produce flower stalks.) Bolting susceptibility may also be variety specific. Sandy or sandy-loam soils are preferred for the early and over-wintered crops. Highest yields are obtained on muck soils. Muck soils have a high water-holding capacity and are well aerated. The ideal pH range for spinach is 6.5–7.5.

Most spinach varieties reach maturity in 40–50 days under good growing conditions. Early spring plantings may require 50–70 days.

Average Yields

Crop	per acre	per hectare
Processing spinach	10,000–12,000 lb	11,000–13,000 kg
Fresh market spinach	400 cartons[1]	1,000 cartons

[1] 24 bunches per carton.

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Sow outside as soon as the soil can be worked, in early spring through to early May. Plant from July 31 to August 31 for a fall crop. Do not sow seed in mid-summer, as bolting may occur. For over-wintered spinach, sow from September 1–10.

Fresh seed will germinate readily at soil temperatures as low as 3°C–4°C (37°F–39°F.) Optimum germination occurs at 10°C–16°C (50°F–61°F). At higher temperatures, there is a more rapid emergence but decreased percentage germination.

	Row Spacing		In-Row Spacing		Seed Required	
Crop	cm	in.	cm	in.	kg/ha	lb/ac
Spinach	30	12	5–10	2–4	12	11
Swiss Chard	30	12	10–12	4–5	12	11

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24). See also Table 6–66, *Spinach Nitrogen Recommendations*, above.

Table 6–66.
Spinach Nitrogen Recommendations

Soil	Actual N kg/ha	Actual N lb/ac
Mineral Soils		
Preplant	55	49
Side-dress	55	49
Total	**110**	**98**
Muck Soils		
Preplant[1]	75	67

[1] On muck soils, if rainfall has been excessive, an additional 55 kg/ha (50 lb/ac) may be side-dressed.

Broadcast and incorporate the recommended preplant nitrogen with all the required phosphate and potash. For early sown crops, apply the total nitrogen recommendation as a preplant application.

Phosphate and Potash

Soil tests are required to determine phosphate and potash requirements. See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, and Table 2–7, *Phosphorus and Potassium Requirements: Vegetables on Muck Soils*, on page 19.

If phosphate and potash are required, apply and incorporate them prior to planting.

Boron

Boron deficiencies on spinach and swiss chard are not common but may occur during periods of hot, dry weather. Leaves become twisted with light spots developing on the petioles. Internal breakdown may occur in the roots. External cankers may also develop on the root surface. See the section *Boron*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Magnesium

A magnesium deficiency may occur on spinach. The usual symptoms are yellowing of older leaves while the veins remain dark green. See the section *Magnesium*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Table 6–67.
Spinach Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL-LS	metalaxyl-m	20–40 mL per 100 kg seed	damping-off	**Export use only.** Not for greenhouse-grown spinach.
Thiram 75 WP	thiram	90 g per 25 kg seed	seed decay and damping-off	

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

For identification and management information, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54. Also see Table 6–67, *Spinach Seed Treatments*, above.

DOWNY MILDEW

Identification: Infection usually begins on the mature, lower leaves and spreads inward. Chlorotic (yellowish) or pale-green areas appear on the upper surface of the leaves. Greyish-purple mould spores develop on the underside of the leaf.

Development: Infection can occur at any growth stage. Cool temperatures of 10°C–15°C (50°F–59°F) and prolonged periods of leaf wetness, dew or fog support development. Downy mildew fungi survive for at least 1 year in the soil and 2 years in infected seed.

Management Notes: Resistant cultivars are available. Follow a 3-year rotation with non-host crops and plant into well-drained soils. Fall spinach crops should not be grown in, or adjacent to, fields where an infected spring crop was grown.

FUSARIUM WILT

Identification: Fusarium wilt causes the outer leaves to wilt and turn yellow. Severe infections may progress to younger leaves. Light brown-to-black lesions develop on the roots, and the water-conducting vessels turn black.

Development: Moist soil conditions are required for initial root infection. Once established, the disease will progress quickly, especially if the soil becomes dry and the plants become stressed. Fusarium wilt is most severe at soil temperatures of 27°C (81°F).

Management Notes: In soils where this is a problem, do not seed spinach from May 31 to August 15. Some genetic tolerance may exist. Maintain a high soil pH; alkaline soils do not favour disease development.

SPINACH BLIGHT, CUCUMBER MOSAIC VIRUS, BEET MOSAIC VIRUS

Identification: Infected plants become stunted with progressive yellowing and mottling. Beet mosaic virus produces small spotting early in the infection period without the distortion of the leaves common to other viruses.

Development: Cucumber mosaic virus is usually transmitted by aphids. Infestations are often associated with high temperatures and high aphid activity.

Management Notes: Virus-resistant cultivars are available. Control weeds in adjacent fencerows. Milkweed, ground cherry, pokeweed, chickweed and mother-wort are alternative hosts to the cucumber mosaic virus. Avoid growing spinach near other mosaic-susceptible vegetable crops.

Insects

APHIDS

For identification and management information on this common pest of many vegetable crops, see the section *Aphids*, on page 54, and Table 6–68, *Spinach and Swiss Chard Insect Control Recommendations*, on page 156.

LEAF MINERS

The pea leaf miner adult causes severe stipling (bronzing) damage to leaves of spinach and swiss chard. Mining of the leaves by pea leaf miner larvae is not as common. For more information, see the section *Leaf Miners*, on page 80. Other species of leaf miner create twisted mines underneath the leaf surface. See Table 6–68, *Spinach and Swiss Chard Insect Control Recommendations*, on page 156.

CABBAGE LOOPER

Cabbage looper can cause sporadic damage in Ontario spinach and swiss chard. Five percent infestation is suggested as a threshold. For more information, see the section *Imported Cabbageworm, Cabbage Looper, Diamondback Moth Caterpillar*, on page 88. See also Table 6–68, *Spinach and Swiss Chard Insect Control Recommendations*, on page 156.

Table 6–68.
Spinach and Swiss Chard Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Leaf Miners						
malathion	organophosphate	Malathion 25 W	5.5–7.0 kg	2.2–2.8 kg	7	**Spinach only.**
diazinon	organophosphate	Diazinon 50 W	1 kg	0.4 kg	10	**Spinach only.**
		Diazinon 500 E	1.1 L	0.44 L	10	
		DZN 600 EW	915 mL	366 mL	10	
Aphids						
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	0.8 L	14	**Spinach only.** Maximum 1 application/yr.
		Endosulfan 50 W	1.75 kg	0.7 kg	14	
diazinon	organophosphate	Diazinon 50 W	1.0 kg	0.4 kg	10	**Spinach.**
		Diazinon 500 E	1.1 L	0.44 L	14	**Swiss chard.**
		DZN 600 EW	915 mL	366 mL		Control of aphids with diazinon has been inconsistent in many areas.
dimethoate	organophosphate	Cygon 480	700 mL	280 mL	7	Maximum 2 applications/season.
		Lagon 480	700 mL	280 mL	7	
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	**Spinach only.** Control of aphids with naled has been inconsistent in many areas.
pirimicarb	carbamate	Pirimor 50 DF	500 g	200 g	7	**Spinach only.** 24-hr re-entry period. Maximum 3 applications/yr.
acetamiprid	cholornicotinyl	Assail 70 WP	56–86 g	22.4–34.4 g	7	**Use high rate to control swede midge.** Maximum 5 applications/yr. Alternate applications with different insecticide groups.
Cabbage Looper, Beet Webworm						
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	**Spinach only.** Looper only.
		Dipel 2XDF	275–550 g	110–220 g	0	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	2 L	0.8 L	14	**Spinach only.** Looper only. Maximum 1 application/yr.
		Endosulfan 50 W	1.75 kg	0.7 kg	14	
naled	organophosphate	Dibrom	1.1–1.65 L	0.44–0.66 L	4	**Spinach only.** Looper only.
spinosad	naturalyte	Success 480 SC	182 mL	73 mL	1	Maximum 3 applications/yr.

[1] DHI = Days to Harvest Interval.

BEET WEBWORM

This is a rare problem in Ontario spinach and Swiss chard crops. However, it can cause sporadic damage. Dark-coloured webworm larvae produce webs on the leaves and petioles. For more information, see the section *Beet Webworm*, on page 71. See also Table 6–68, *Spinach and Swiss Chard Insect Control Recommendations*, above.

For more information on spinach and Swiss chard IPM, consult the following OMAF Factsheets:

- *Leaf Miners Attacking Field Vegetables and Greenhouse Crops*, Order No. 00-039
- *Caterpillar Pests of Crucifer Crops*, Order No. 99-035

Nematode Control

To avoid damage from sugarbeet cyst nematode, do not plant spinach following rhubarb, beets or spinach. (See the section *Nematodes*, on page 57.)

Harvest and Storage

Spinach can be harvested when it has five or six leaves. Higher yields result when plants have 10–12 leaves. Most of the Ontario crop is machine harvested. Spinach is usually washed before marketing.

Remove the field heat from spinach as soon as possible after harvest. Stored product may last for 10–14 days, under good conditions. Store at 0°C (32°F) and a relative humidity of 95%–100%.

SUGARBEETS

Production Requirements

Sugarbeets can be grown on a wide range of soil types. It is important to have good surface and subsurface drainage. Plant sugarbeets as early as possible for maximum yield potential. Early harvest can begin in late September, while main harvest runs from mid-October into November.

Average Yields

Crop	per acre	per hectare
Sugarbeets with sugar levels of 17%–19%	21–25 tons	47–55 tonnes

Cultivars

Follow processor's requirements.

Seeding and Spacing

Plant enough seed to give an emerged stand of 150–180 sugarbeets per 30 m (100 ft) of row. See Table 6–69, *Sugarbeet In-Row Spacing*, right. These spacings will consistently produce more recoverable sugar per area than lower stands. The use of coated and primed seed improves plant emergence.

Proper planter set-up and maintenance are extremely important for successful establishment of the sugarbeet stand. Good seedbed preparation is also important for achieving early seeding dates, rapid seedling emergence and a uniformly spaced stand. Deep or excessive spring tillage reduces soil moisture and increases crusting, impacting sugarbeet emergence. Planting depth will vary with soil types and moisture conditions. A depth of 2.5 cm (1 in.) is generally satisfactory.

Table 6–69.
Sugarbeet In-Row Spacing
Based on 50–55 cm (20–22 in.) row width

	Seed spacing needed to achieve:			
	180 sugarbeets		150 sugarbeets	
Expected % Emergence[1]	per 30 m (100 ft) of row			
	cm	in.	cm	in
40	6.8	2.7	8.1	3.2
50	8.4	3.3	10.2	4.0
60	10.2	4.0	12.2	4.8
70	11.9	4.7	14.2	5.6
80	13.5	5.3	16.3	6.4

[1] Normal emergence is approximately 60% in our growing areas. Aim for a minimum emergence of 180 sugarbeets/30 m (100 ft) in 71–76 cm (28–30 in.) rows and 150 sugarbeets/30 m (100 ft) in 51–56 cm (20–22 in.) rows.

Fertility

pH

Sugarbeets will perform best at a pH of 6.5–7.2. Manganese deficiency may become a problem above pH 7.2.

Soil pH can have a significant impact on the breakdown of several commonly used field crop herbicides.

imazethapyr (Pursuit, Clean Sweep)	degrades very slowly at pH less than 6.0–6.5.
flumetsulam (Broadstrike Dual, Fieldstar)	breaks down very slowly below a pH of 6 and above a pH of 7.8.
cloransulam (First Rate)	breaks down very slowly below a pH of 6 and above a pH of 7.8.
chlorimuron-ethyl (Classic)	degradation stops at a pH greater than 7

Carryover of these herbicides will severely injure sugarbeets. It takes time after the application of lime for the pH to fully adjust. Allow for sufficient time for herbicide breakdown after the pH adjustment. Even where the average pH of a field is suitable, areas of low or high pH may still exist.

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

After field corn, use 120–150 kg N/ha (107–134 lb/ac). Reduce nitrogen application to 100–130 kg (89–116 lb/ac) when following other crops. Excess nitrogen will not increase sugarbeet yield. It often has an adverse effect on sugar content and clear juice purity.

Phosphate and Potash

Soil tests should be used to determine phosphate and potash requirements. Excess application of potassium will lead to luxury consumption by the sugarbeet plant. This has a negative effect on clear juice purity. See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.

Starter Fertilizer

Fields with high soil test levels of phosphorus and potassium do not generally require starter fertilizer. When band-

Table 6–70.
Sugarbeet Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Apron XL LS	metalaxyl-M	20–40 mL per 100 kg seed	damping-off, root rots	For use in commercial seed treatment plants only.
Thiram 75 WP	thiram	90 g per 25 kg seed	seed decay, damping-off	Do not feed treated clippings to livestock.
Apron FL	metalaxyl	93 mL per 100 kg seed	pythium seed rot, seedling blight	
Allegiance FL	metalaxyl	93 mL per 100 kg seed	pythium seed rot, seedling blight	

ing, place starter fertilizer at least 5 cm (2 in.) to the side and 5 cm (2 in.) below the seed to avoid seedling injury.

Manganese

Manganese deficiencies are more common on heavier textured soils with high pH and higher soil organic matter levels. Deficient plants show marked yellowing between the leaf veins; the veins themselves remain green. If soybeans regularly exhibit manganese deficiencies in the field, then manganese deficiency may also occur in sugarbeets. To correct a deficiency, spray with manganese sulfate, see the section *Manganese*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

Diseases

DAMPING-OFF AND ROOT ROTS

Varieties recommended by the processor have considerable tolerance to seedling diseases and damping-off. See Table 6–70, *Sugarbeet Seed Treatments*, above, and the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54.

CERCOSPORA LEAF SPOT

Identification: Numerous small, circular lesions develop on the leaves. Small black dots can be seen with a hand lens in the centre of the lesions. Cercospora leaf spot can lead to defoliation and reductions in both yield and sugar content.

Development: Cercospora leaf spot is most active from mid-July through early September. Air temperatures above 24°C (75°F) with extended periods of leaf wetness due to rain, heavy dews, or fog are favourable for disease development.

Thresholds: Use BEETCAST (see right, above) to determine optimum fungicide timing. Begin preventative spray programs before leaf symptoms appear.

Management Notes: Approved sugarbeet varieties have varying levels of leaf spot tolerance. The initial spray should be a systemic fungicide (Senator or Headline).

BEETCAST

The BEETCAST program uses temperature and leaf wetness measurements to schedule preventative fungicide applications, before the damaging disease symptoms are visible. BEETCAST assigns a Disease Severity Value (DSV) for each day and location. A zero DSV is used when conditions are not favourable to disease development, due to cool temperatures or dry leaves. Favourable conditions, due to warm temperatures and extended periods of leaf wetness, are given a DSV of 4. Spray applications are made when the accumulated daily DSVs reach a target number.

BEETCAST DSVs are available from the Ontario Weather Network at Ridgetown College, with support from the Ontario Sugarbeet Growers' Association. For more information, contact the Ontario Weather Network at (519) 674-1532 or visit their Web site at www.ownweb.ca.

Apply a contact fungicide (mancozeb) for resistant management if a third application is required. As fall temperatures drop below 15°C (59°F), no further sprays are warranted. See Table 6–71, *Sugarbeet Disease and Insect Control Recommendations*, on page 159.

RHIZOCTONIA CROWN ROT

Identification: Crown rot initially attacks the base of the plant, causing wilting and death of the foliage. Severe infections may cause decay of the crown and root.

Development: Rhizoctonia crown rot is a warm weather disease. It becomes active late in the season, at temperatures of 25°C–33°C (77°F–91°F).

Management Notes: Avoid throwing soil onto sugarbeet crowns during cultivation. Rotate with corn or small grains. Do not dump sugarbeet tare dirt onto fields going into sugarbeets the following year.

Table 6–71.
Sugarbeet Disease and Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cercospora Leafspot						
thiophanate-methyl	benzimidazole	Senator 70WP	0.42–0.56 kg	0.17–0.22 kg	21	Systemic. Always rotate with contact type compound. Follow an IPM and resistance management strategy. Maximum 1 application per season.
mancozeb	dithiocarbamate	Manzate 200 DF	2.25 kg	0.9 kg	21	Apply every 7–10 days.
		Dithane	2.25 kg	0.9 kg	21	
		Penncozeb 80 WP	2.25 kg	0.9 kg	21	
cupric hydroxide	inorganic	Kocide 101	2.25–4.5 kg	0.9–1.8 kg	1	Apply every 10–14 days. Add suitable non-herbicidal agricultural oil at 5.5 L/ha.
copper hydroxide	inorganic	Parasol WP	2.25–4.5 kg	0.9–1.8 kg	1	Apply at 10–14-day intervals once disease is detected. Add suitable non-herbicidal agricultural oil at 5.5 L/ha.
pyraclostrobin	strobilurin	Headline EC	670–900 mL	268–360 mL	7	Use high rate when disease pressure is high. Also controls powdery mildew. Maximum 4 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
Wireworm, Sugarbeet Maggot						
terbufos	organophosphate	Counter 15 G	45 g/100 m of row	13.7 g/100 ft of row		Apply at planting. Do not place in direct contact with seed. Rates based on minimum 50 cm (20 in.) spacing.
Cutworms						
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.5–1.0 L	90	24-hr re-entry period.
Flea Beetles, Leafhoppers, Spider Mite						
malathion	organophosphate	Malathion 500 E	1.1 L	0.44 L		Flea beetles. Apply at the 3–5-leaf stage when insects or damage first appears.
naled	organophosphate	Dibrom	2.2 L	0.9 L	5	Red spider mites, leafhoppers.
Sugarbeet Cyst Nematode						
dichloropropene/ chloropicrin		Telone C-17	160 L	65 L	120	Mineral soils. Applied before planting. 72-hr re-entry period.

[1] DHI = Days to Harvest Interval.

Note: As the Ontario sugarbeet crop is processed entirely in the United States, all products used must have both Canadian and U.S. registrations on sugarbeets. Your processor may have specific restrictions and recommendations. Check with your processing company representative before spraying.

Insects

CUTWORMS, WIREWORMS

For identification and management information on these common vegetable insects affecting sugarbeets, see *General Insects and Diseases of Vegetable Crops*, on page 54.

FLEA BEETLES

Identification: These small, black beetles create shot holes in the leaves. Springtails may be confused with flea beetles.

Period of Activity: Early in the season.

Thresholds: This pest does not usually cause economic injury in Ontario. Control may be necessary if 25% or more of seedlings show flea beetle damage.

Management Notes: See Table 6–71, *Sugarbeet Disease and Insect Control Recommendations*, above.

ROOT APHIDS

Root aphids are a localized but serious pest in some years. Look for woolly spots, waxy exudate or the presence of aphids on roots. Certain approved sugarbeet varieties have tolerance to this pest.

LEAF MINERS, LEAFHOPPERS, SPIDER MITES

These pests are often present in Ontario sugarbeet fields. However, they do not usually cause economic damage. If populations build to damaging levels, see Table 6–71, *Sugarbeet Disease and Insect Control Recommendations*, on page 159.

Lamb's-quarters is an alternate host for leaf miners. Good weed control can reduce infestations.

Sugarbeet Cyst Nematode

Rotation to non-host crops for 4–5 years will significantly reduce populations of this nematode. Avoid rotation with other host crops including table beets, cruciferous crops and rhubarb. (See the section *Nematodes*, on page 57.)

Harvest and Storage

Handle sugarbeets as gently as possible to minimize breakage and bruising. Damaged sugarbeets will not store well in piles. Adjust flails to remove all green leaf material from the crowns. Flail only the amount of sugarbeets to be harvested each day. Topped beets will freeze in the field much more quickly than beets with tops.

Frosted or frozen sugarbeets deteriorate rapidly in the pile. When sugarbeet crowns are frosted or frozen in the field, delay harvest until the tissue has had a chance to thaw and stabilize.

SWEET CORN

Production Requirements

Sweet corn is well adapted to a wide range of growing conditions in Ontario. Sweet corn is sensitive to cold soils and frost and performs best under warm growing conditions. Early-season production is well suited to warm, sandy-loam soils. Later plantings benefit from the higher moisture-holding capacity of clay-loam soils.

Sweet corn maturity ranges from 60–100 days, depending on the variety. Fresh market sweet corn is usually picked 21 days after 50% silk. Processing crops are harvested slightly later.

Average Yields

Crop	per acre	per hectare
Processing	5–7 tons	11–15 tonnes
Fresh market	1,000 doz (200 bags)	2,500 doz (500 bags)

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

Seeding and Spacing

Row spacing: 75–90 cm (30–36 in.)
In-row spacing: 20–25 cm (8–10 in.)
Rate: 11–17 kg seed/ha (10–15 lb/ac)
Depth: 4–7.5 cm (1.5–3 in.)

Soil Temperature

The optimum soil temperature range for sweet corn is 15°C–35°C (59°F–95°F.) The minimum soil temperature needed for germination depends on the cultivar and its gene type. Crops planted into cold soils suffer from delayed, uneven emergence. Cold soils also increase the risk of losses to early-season pests, such as 3-leaf dieback, seedcorn maggots and wireworms.

Gene Type	Minimum Soil Temperature
Normal (su)	13°C (55°F)
Sugar-enhanced (se)	16°C (61°F)
Supersweet (sh_2)	18°C (64°F)

Isolation

All sweet corn must be isolated from field corn. Supersweet (sh_2) varieties must be separated from both normal (su) and sugar enhanced (se) varieties. Cross pollination will turn the kernels of the sh_2 variety starchy. If se varieties are pollinated with su pollen, they will revert back to normal sugar levels.

Yellow is the dominant colour gene. Isolation of white varieties is necessary to avoid colour contamination. Bicolour cobs pollinated with yellow pollen will have a lower proportion of white kernels. Separate indian corn from all types of sweet corn. It will cause black kernels to appear in the cobs.

Separate incompatible varieties by at least 100 m (350 ft) or schedule the plantings so that pollen-shed is 2 weeks apart.

Fertility

Nitrogen

If manure is applied or legume sod is plowed down, reduce the nitrogen (N) application. (See Table 2–12, *Adjustment of Nitrogen Requirement Where Sod Containing Legumes Is Plowed Down*, on page 23, and Table 2–13, *Average Amounts of Available Nutrients for Different Types of Manure*, on page 24.)

On all soils, 90 kg N/ha (80 lb/ac) is recommended.

APPLICATION

Apply a portion of the nitrogen and potash required at seeding in one of two ways:

1. In a band 5 cm (2 in.) to the side and 5 cm (2 in.) below the seed, apply as follows:

Fertilizer	Maximum Application Rates[1]	
	kg/ha	lb/ac
Nitrogen	75	67
Nitrogen plus potash	75 + 45	67 + 40
Urea	40	36
Urea plus potash	40 + 40	36 + 36

[1] Based on 75-cm (30-in.) rows

2. In a band directly with the seed:

- Do not use more than 9 kg nitrogen-plus-potash/ha (8 lb/ac).
- Do not place urea with the seed.

A major portion of the nitrogen should be applied preplant or side-dressed before the corn is 30 cm (12 in.) high. Avoid "pop-up" starter fertilizers that use urea as the nitrogen source. If the N component is more than half as much as the P component, the starter may contain urea.

Table 6–72.
Sweet Corn Seed Treatments

Trade Name	Active Ingredients	Rate	Pests Controlled	Notes
Insecticide and Fungicide Combinations				
DCT	diazinon-captan-thiophanate-methyl	125 g per 25 kg seed	seed maggots, seedling blights, including *Penicillium* spp.	
Agrox B-2	diazinon plus captan	85 g per 25 kg seed	seed and root maggots, damping-off and seedling blights	Use within one month of treatment.
Agrox CD	diazinon plus captan	50 g per 25 kg seed	seed and root maggots, wireworms, damping-off and seedling blights	Use on seed previously treated with captan or thiram.
Fungicide Only				
Apron XL LS	metalaxyl-M	20–40 mL per 100 kg seed	damping-off and root rot	For use in commercial seed treatment plants only. Tank-mix with Maxim 480 FS.
Maxim 480 FS	fludioxonil	5.2–10.4 mL per 100 kg seed	damping-off, seedling blights, including *Penicillium* spp.	For use in commercial seed treatment plants only. Tank-mix with Apron XL LS.
Captan FL	captan	60–85 mL per 25 kg seed	seed decay, damping-off and seedling blights	For use in commercial seed treatment plants only.
Thiram 75 WP	thiram	55 g per 25 kg seed	seed decay and damping-off	Do not feed treated clippings to livestock.
Apron FL	matalaxyl	46–110 mL per 100 kg seed	pythium seed rot and seedling blight.	Do not feed crop to livestock for 4 weeks after planting.
Allegiance FL	matalaxyl	46–110 mL per 100 kg seed	pythium seed rot and seedling blight.	Do not feed crop to livestock for 4 weeks after planting.
Insecticide Only				
Gaucho 480 FL	imidacloprid	520 mL per 100 kg seed	flea beetles and wireworms	For use in commercial seed treatment plants only.
Poncho 600	clothianidin		wireworm, seedcorn maggot, corn root worm, white grubs, flea beetles	For use in commercial seed treatment plants only.

Phosphate and Potash

Use a soil test to determine phosphate and potash requirements. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

A major portion of the potash may be broadcast and incorporated either in the fall or before seeding in the spring. Phosphate is best banded at the time of planting. Depending on the soil test rating, additional broadcast P applications may not be necessary.

Zinc

Visual symptoms on the leaves are the best means of determining deficiency, but soil tests are also useful. Where zinc is required, it may be applied to the soil mixed in the fertilizer. Foliar-applied zinc is often an efficient way of correcting zinc deficiencies. See the section *Zinc*, on page 22, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Integrated Pest Management

Diseases

THREE-LEAF DIEBACK

Seedlings may die before or shortly after emergence, resulting in poor stand establishment. Two fungi are responsible: *Penicillium* occurs as a contaminant on the seed, whereas *Pythium* is common in most soils. Seeds planted into cool soils and sh2 varieties are most susceptible.

To prevent three-leaf dieback, use one of the fungicide seed treatments listed in Table 6–72, *Sweet Corn Seed Treatments*, above. Seed treatments usually provide 2 weeks of protection to the seed. Planting into suitably warm soils and ensuring rapid germination is the best protection against three-leaf dieback. For more information, see the section *Damping-Off and Root Rots (Pythium, Phytophthora, Rhizoctonia, Fusarium, Pennicillium)*, on page 54.

STEWART'S WILT

Identification: Plants infected before the 5-leaf stage become stunted, wilt and die. Later infections cause pale green or yellow stripes, running parallel to the leaf veins. Late damage is easily confused with magnesium deficiency. Wilt-infected plants, cut at the base, will exhibit brown, mushy tissue inside the stem.

Development: This disease is transmitted by the corn flea beetle. Yield losses are most significant when susceptible varieties are infected before the 7-leaf stage. Losses at this stage may range from 40%–100%.

Management Notes: Mild winters favour flea beetle survival and increase the risk of problems the following season. There is no control for this disease, however, many varieties have excellent resistance to the Stewart's wilt bacteria. Corn flea beetle control may help prevent the spread of the Stewart's wilt bacterium. See the section *Corn Flea Beetle*, below, for more information.

RUST

Identification: Reddish-brown (rusty) pustules develop on the upper leaf surface. The size of each lesion ranges from 1–3 mm. Older pustules turn blackish-brown.

Development: Rust infection requires cool weather (16°C–23°C or 61°F–73°F) and 3–6 hours of leaf wetness. Heavy overnight dews favour development. The rust fungi does not overwinter in Ontario. Epidemics arise from spores blown in from the United States and Mexico.

Thresholds: Prior to silking, plants with more than 6 pustules per leaf will benefit from a fungicide application.

Management Notes: There is a wide range of rust resistance in sweet corn cultivars. Rust infections occurring after silk emergence are unlikely to result in yield losses. See Table 6–73, *Sweet Corn Insect and Disease Control Recommendations*, on page 164.

Insects

SEEDCORN MAGGOTS, WIREWORMS, CUTWORMS, APHIDS, SLUGS, GRUBS

For identification and management information on these common vegetable insects affecting sweetcorn, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, and Table 6–72, *Sweet Corn Seed Treatments*, on page 162, and Table 6–73, *Sweet Corn Insect and Disease Control Recommendations*, on page 164.

CORN FLEA BEETLE

Identification: These small (2-mm) black beetles cause elongated scratches on the leaves and transmit the Stewart's wilt virus. Beetle feeding itself does not cause yield losses.

Period of Activity: Beetles overwinter in the top 5 cm (2 in.) of the soil/residue. They emerge when soil temperatures reach 18°C (64°F.) The first peak of activity is in late June. Mild winters favour beetle survival and increase the risk of Stewart's wilt transmission.

Thresholds: Susceptible varieties may require foliar control if more than 10% of the plants have severe feeding injury or there are more than 2 beetles per plant.

Management Notes: Susceptibilty to Stewart's wilt varies greatly between varieties. Many early hybrids are particularly vulnerable. Insecticide seed treatments provide the best early-season control of emerging flea beetles. See Table 6–72, *Sweet Corn Seed Treatments*, on page 162. Foliar insecticides applied for cutworm control may also reduce adult flea beetle populations.

EUROPEAN CORN BORER

Identification: Full-grown corn borer larvae are 2.5 cm (1 in.) in length. They are a greasy white colour, with a dark head and spots on each segment. Eggs are shiny, white and laid in clusters of 30 that resemble fish scales. Corn borer larvae feed briefly on the leaves but soon tunnel into the protection of the stalk. As the crop matures, borers move from the stalk into the ear.

Period of Activity: Borers overwinter as pupae in corn stubble. Southwestern Ontario experiences two generations per year. Usually, the first-generation adults emerge in mid-June, and the population peaks in mid-July. Second-generation populations peak in August. In the rest of the province, single-generation corn borers usually emerge in late June or early July. Populations peak in late July to early August. Many areas within southwestern Ontario (Lambton, Middlesex, Oxford, Brant, Norfolk and Niagara) have an overlap of corn borer generations. These areas experience a sustained peak flight for much of July and August.

Sweet corn is susceptible to corn borer from the late-whorl stage (12–14 leaves) until harvest.

Thresholds: 5% feeding injury or the presence of eggs warrants an insecticide application.

Management Notes: Begin monitoring at the mid-whorl stage. If monitoring indicates a need, apply the first spray at tassel emergence. Direct the sprays down into the whorl and at the developing ears. Applications at 5–7-day intervals usually give satisfactory control. See Table 6–73, *Sweet Corn Insect and Disease Control Recommendations*, on page 164.

Table 6–73. Sweet Corn Insect and Disease Control Recommendations

Common Name	Group[1]	Trade Name	Rate per Hectare	Rate per Acre	DHI[2]	Notes
Rust						
propiconazole	triazole	Tilt 250 E	500 mL	200 mL	14	Under severe disease pressure, make second application in 14 days.
chlorothalonil	chloronitrile	Bravo 500	3.2 L	1.3 L	14	Maximum 2 applications/yr.
European Corn Borer						
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33.2 mL	1	Maximum 3 ground applications or 2 aerial applications/yr. 24-hr re-entry period.
permethrin	pyrethroid	Pounce	275–375 mL	110–150 mL	1	Aerial application permitted.
cypermethrin	pyrethroid	Cymbush 250 EC	280 mL	112 mL	5	Maximum 3 ground applications or 2 aerial applications/yr.
		Ripcord 400 EC	175 mL	70 mL	5	
deltamethrin	pyrethroid	Decis 5 EC	250–300 mL	100–120 mL	5	Maximum 2 ground or 1 aerial applications/yr.
carbaryl	carbamate	Sevin XLR plus	2.5–4.0 L	1–1.6 L	1	
methomyl	carbamate	Lannate	625 g	250 g	3	24-hr re-entry period.
acephate	organophosphate	Orthene 75 SP	0.75–1.1 kg	0.3–0.44 kg	21	Maximum 4 applications/yr.
carbofuran[3]	carbamate	Furadan 480 F	1.1 L	0.44 L	7	Maximum 2 applications/yr. 48-hr re-entry period.[2]
Bacillus thuringiensis	biological	Dipel 2X DF	0.56–1.12 kg	0.22–0.44 kg		Apply when pinhole feeding is observed on 5% of plants.
		Bioprotec CAF	2.8–4.0 L	1.1–1.6 L		
spinosad	naturalyte	Success 480 SC	83 mL	33.2 mL	7	Use only on very small larvae and low populations. Do not apply within 28 days of forage harvest. Maximum 2 applications/yr.
Corn Earworm, Fall Armyworm						
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33.2 mL	1	Maximum 3 ground applications or 2 aerial applications/yr. 24-hr re-entry period.
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	5	Maximum 3 ground applications or 2 aerial applications/yr.
permethrin	pyrethroid	Pounce	275–375 mL	110–150 mL	1	Earworm. Aerial application permitted.
			180 mL	72 mL	1	Fall armyworm. Aerial application permitted.
deltamethrin	pyrethroid	Decis 5 EC	250–300 mL	100–120 mL	5	For earworm only. Maximum 2 applications/yr.
methomyl	carbamate	Lannate	430–625 g	172–250 g	3	For earworm only. 24-hr re-entry period.
Aphids						
pirimicarb	carbamate	Pirimor 50 DF	550 g	220 g	3	Ground application. 450 L of water/ha.
					3	Aerial applications. 20–45 L of water/ha. Maximum 1 application/yr.
Corn Rootworm, Wireworm and Seedcorn Maggot						
tefluthrin	pyrethroid	Force 3.0 G	37.5 g per 100 m of row			Apply in-furrow at planting.
carbofuran	carbamate	Furadan 480 F	500 mL	200 mL	7	Rootworm adults only. 48-hr re-entry period.
Cutworms						
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33.2 mL		Apply up to 5-leaf stage. 24-hr re-entry period. Do not disturb soil for 5 days after application.
permethrin	pyrethroid	Pounce	180–390 mL	72–156 mL		Apply up to 5-leaf stage. Do not disturb soil for 5 days after application.
cypermethrin	pyrethroid	Ripcord 400 EC	175 mL	70 mL	21	
chlorpyrifos	organophosphate	Lorsban 4E	1.2–2.4 L	0.48–0.96 L	70	24-hr re-entry period.
		Pyrinex 480 EC	1.2–2.4 L	0.48–0.96 L	70	24-hr re-entry period.
Slugs						
ferric phosphate	inorganic	Sluggo	25–50 kg	10–20 kg	0	Use high rates on severe infestations.

[1] Pyrethroid sprays rapidly degrade at temperatures over 26.5°C (80°F) and more frequent spray applications are often required. Spraying during cooler evening temperatures may increase the performance of these products.

[2] DHI = Days to Harvest Interval.

[3] If prolonged direct contact with corn foliage will occur, do not re-enter treated fields between 2–14 days of application without wearing appropriate protective clothing such as long pants and a long-sleeved shirt.

Table 6–74.
Corn Earworm Spray Intervals
Based on trap counts.

Moths/trap per week	Spray Intervals	
	<27°C (81°F)[1]	≥27°C (81°F)
1–6	5–7 days	5–7 days
7–90	5 days	4 days
More than 90	4 days	3 days

[1] Daily maximum temperature.

Transgenic varieties (Bt Sweet Corn) have complete resistance to corn borers and partial resistance to earworms and fall armyworms. Insecticides may be needed for other pests if pressure is high. Check with your seed company representative for availability and planting restrictions.

CORN EARWORM

Identification: Earworm larvae range in colour from yellowish, to green or brown, with a fine double stripe running down their backs. The larvae are slightly larger than the European corn borer. Earworm adults lay their eggs on corn silk, and the larvae are usually found in the top third of the ear.

Period of Activity: Corn earworms do not overwinter in Ontario. They arrive from the United States and Mexico on tradewinds. In southwestern Ontario, adult moths usually appear in mid-to-late July, or earlier, depending on the season. In eastern and northern areas, arrival occurs in mid-to-late August. In cooler years, these areas may not experience corn earworm at all.

Earworm activity is highest in hot weather conditions. Peak flights often occur immediately after severe thunderstorms.

Thresholds: Use pheremone traps to monitor corn earworm populations. Insecticide applications are based on the number of moths caught per week and the average temperatures. See Table 6–74, *Corn Earworm Spray Intervals*, above.

Management Notes: Sweet corn is only susceptible to corn earworm damage while the silks are green. Good spray coverage of the rapidly growing silks is important. Pyrethroid sprays break down quickly under high temperature conditions, and more frequent spray applications are required.

See Table 6–73, *Sweet Corn Insect and Disease Control Recommendations*, on page 164.

FALL ARMYWORM

Fall armyworm are also migratory pests. They usually arrive in Ontario slightly later than the corn earworm. The pale-green or tan-coloured larvae create large, rough holes in the leaves and the cob. The spray threshold is 5% feeding injury. However, sprays used for corn borer and corn earworm usually control the armyworm as well.

CORN ROOTWORM

Corn rootworm adults lay their eggs in the fall in corn fields. The following spring, emerging larvae will feed on corn roots. They weaken the root system, often causing lodging (or goosenecking). Crop rotation will almost always control corn rootworm populations.

Adult beetles occasionally feed on corn silks in late July–early August. Populations are usually kept under control by corn borer and earworm sprays. Severe feeding may result in poor kernel set.

For more information on integrated pest management in sweet corn, see the following OMAF Factsheets and publications:

- *European Corn Borer in Sweet Corn and Other Horticultural Crops*, Order No. 97-019
- *Corn Earworm*, Order No. 95-065
- Publication 12, *Sweet Corn Production Manual*

Bee Warning

Bees often visit sweet and field corn to collect water and pollen. Spraying may cause bee poisoning. Sevin, Furadan and Pounce are highly toxic to bees. Damage to bees is reduced when sprays are applied in early morning or late evening when bees are not foraging. Do not treat when the wind is blowing. Avoid spray drift to roadsides and adjacent fields where plants might be in bloom.

Advise local beekeepers of spraying activity (see the section *Prevent Bee Poisoning*, on page 8)

Birds

RED-WINGED BLACKBIRDS AND CROWS

Acetylene exploders (bird bangers) are effective, but birds will soon resume feeding when exploders are not operating. For full effectiveness, start using the bangers before

the corn becomes attractive for feeding and move them around frequently. Avoid planting near marshy and wooded areas. Cultivars with ears well-covered by husks are somewhat resistant to bird damage. For complete bird control information, see the section *Birds*, on page 59.

Harvest and Storage

Sweet corn is harvested while the kernels are at the early milk stage. Eating quality declines quickly if cobs are left in the field past this stage. Under good storage conditions, supersweet varieties may last for up to one week. Normal (su) and sugar enhanced (se) varieties lose quality quickly after 2–3 days.

Remove the field heat from the crop as quickly as possible after harvest. Store at temperatures below 5°C (40°F) with a relative humidity of 95%–98%.

TOMATOES

Production Requirements

Tomatoes perform well on a wide range of mineral soil types, but good drainage is essential. Lighter soils produce earlier crops and facilitate mechanical harvesting. A soil pH range of 6.0–6.8 is optimal.

In Ontario, tomatoes are established using greenhouse-produced transplants. See the section *Vegetable Transplants*, on page 175, for information on transplant production. Fresh-market varieties grown in Ontario require 58–80 days from transplanting to harvest. Processing varieties require from 100 to over 130 days. Harvest begins 6–10 weeks after pollination.

Average Yields

Crop	per acre	per hectare
Fresh market	8–14 tons	18–31 tonnes
Cherry tomatoes	2.5–3.5 tons	5.5–8 tonnes
Processing	30–36 tons	67–80 tonnes

Cultivars

Growers are encouraged to conduct their own field trials to evaluate varieties under local growing conditions. See Appendix E, *Vegetable Seed Suppliers*, on page 191.

See the section *Vegetable Transplants*, on page 175, for information on producing tomato transplants.

Plant Spacing

Table 6–75, *Tomato Plant Spacing*, right, shows spacing for both fresh market and processing types of tomatoes. Machine harvest varieties benefit from a twin row system, grown on a flat or raised bed. If harvesting equipment will allow, the single row system will provide equivalent yields and may reduce foliage and fruit disease.

Plasticulture for Fresh Market Tomatoes

The advantages of using plastic mulch include early yield, improved weed control (with black plastic) and improved fruit quality. The use of row covers can promote faster early-season growth. However, row covers do not provide significant frost protection. For more information, see the section *Plasticulture*, on page 41.

Table 6–75.
Tomato Plant Spacing

Type	Row Spacing	In-Row Spacing	Bed Centres
Fresh Market			
Large vined (indeterminate)	1.5–1.8 m (5–6 ft)	50–70 cm (20–27 in.)	
Small vined (determinate and semi-determinate)	0.9–1.5 m (3–5 ft)	30–60 cm (12–24 in.)	
Processing (Machine Harvest)			
Twin row system	45 cm (18 in.)	45 cm (18 in.)	1.5–1.65 m (5–5.5 ft)
Small vined (early maturing)	45 cm (18 in.)	33 cm (13 in.)	1.5–1.65 m (5–5.5 ft)
Single row system	75 cm (30 in.)	45 cm (18 in.)	

Fertility

Nitrogen

FRESH MARKET TOMATOES

Preplant 35–50 kg N/ha (31–45 lb/ac)

Side-dress 35–50 kg N/ha (31–45 lb/ac)
(Applied after the first fruit are set.)

Avoid late side-dress applications. They may prune the roots and cause blossom-end rot. If additional nitrogen is required late in the season, it may be injected through the irrigation system.

PROCESSING TOMATOES

The nitrogen rate will vary greatly, according to the variety, soil type, crop rotation, organic matter and soil management. Apply nitrogen as a preplant broadcast application according to the recommendations in Table 6–76, *Processing Tomatoes Nitrogen Recommendations*, below.

Table 6–76.
Processing Tomatoes
Nitrogen Recommendations

Soil	Actual N	
	Hybrid	Open-Pollinated
Coarse sand and sandy loams <2% organic matter	160–180 kg/ha (142–160 lb/ac)	100–120 kg/ha (89–107 lb/ac)
Loams, silt loams and sandy loams >2% organic matter	90–120 kg/ha (80–107 lb/ac)	70–90 kg/ha (62–80 lb/ac)

Table 6–77.
Fertigated Tomatoes
Nitrogen Recommendations

Soil	per hectare	per acre
Preplant	35–50 kg	35–50 lb
Transplanting to fruit set	2.5 kg/week	2.2 lb/week
Fruit sizing to harvest	5 kg/week	4.5 lb/week
Harvest	2.5 kg/week	2.2 lb/week

FERTIGATED TOMATOES

Broadcast and incorporate the recommended preplant nitrogen with all the required phosphate and half the required potash. Inject equal amounts of soluble nitrogen and potash according to the schedule in Table 6–77, *Fertigated Tomatoes Nitrogen Recommendations*, above. Do not inject fertilizers containing phosphorus through the drip line.

A cover crop should be seeded after harvest is completed; this will protect soil and reduce erosion. In addition, the cover crop will absorb and tie up left-over nitrogen fertilizer and reduce leaching.

Phosphate and Potash

Use a soil test to determine phosphate and potash requirements. Phosphate and potash fertilizer should be applied as a broadcast application, prior to planting. On most soil types, a fall application of potassium and phosphorus is acceptable. (See Table 2–5, *Phosphorus Requirements: Vegetables on Mineral Soils*, on page 18, and Table 2–6, *Potassium Requirements: Vegetables on Mineral Soils*, on page 19.)

STARTER SOLUTION (ALL TOMATOES)

Apply a high phosphorus starter fertilizer in the transplant water when transplanting tomatoes. Starter fertilizer is especially important when planting in cool soils. Starter fertilizers are available in several forms including liquids (10-34-0 or 6-24-6) or granular materials (10-30-20 or 10-52-10). Apply according to the recommendations in Table 6–78, *Tomato Starter Solution Recommendations*, right.

Magnesium

A magnesium deficiency may occur on tomatoes. The usual symptoms are yellowing of older leaves while the veins remain dark green. See the section *Micronutrients*, on page 20, and Table 2–8, *Application Rates for Magnesium, Calcium and Micronutrients*, on page 21.

Table 6–78.
Tomato Starter Solution Recommendations
For sandy soils with less than 2% organic matter, use half the recommended rates.

Soil Temperature	Starter Concentration
<18°C (64°F)	Use full label rate as recommended.
18°C–27°C (64°F–81°F)	Use half of recommended rate.
>27°C (81°F)	Starter not normally required.

Integrated Pest Management

Diseases

TOM-CAST

The TOM-CAST program is available in some growing areas to help field tomato growers determine the optimum time to apply foliar fungicides for the control of early blight, septoria leaf spot and anthracnose.

A network of weather stations monitor conditions affecting disease development. The weather data is used to calculate disease severity values (DSVs) throughout the growing season. Growers are advised to spray when a critical number of DSVs have accumulated since planting or since the last fungicide application. For more information, contact the Ontario Weather Network at (519) 674-1532 or see their Web site at www.ownweb.ca.

If the TOM-CAST service is unavailable, begin a preventative spray program when the first fruits are about walnut size (or when first fruits appear on early cultivars). Repeat sprays as necessary. Follow 5–7-day intervals during continuous moist weather. Extend the schedule to 12–14 days in warm, dry weather if diseases are under control. Applications should continue until mid-September.

ANTHRACNOSE

Identification: Fruit symptoms appear as small, sunken, water-soaked, circular spots. Lesions gradually expand to 20 mm (¾ in.) in diameter, developing a pattern of concentric rings. The lesions darken and small black fungal structures appear in the centre.

Development: Infections can take place under a wide range of temperatures from 10°C–30°C (50°F–86°F). Rapid development occurs during periods of prolonged leaf wetness. While symptoms appear only on ripe fruit, infection can be initiated on green fruit.

Thresholds: See the section *TOM-CAST*, on page 168. There is little tolerance for anthracnose in processing crops, where fruit must be held in the field and the taste of the product can be affected.

Management Notes: Follow a minimum 3-year rotation with non-solanaceous crops. Control weeds that can act as hosts. Use disease-free or treated seed. Properly timed fungicide sprays are effective at reducing losses to this disease. See Table 6–79, *Tomato Disease Control Recommendations*, on page 170.

EARLY BLIGHT

Identification: Circular spots with dark, concentric rings (target spots) develop on the older foliage. Severe infections spread to younger leaves. Fruit infection may appear as a blackened area at the stem-end.

Development: Early blight overwinters in infected crop residue. Spores are present throughout the growing season and may be carried long distances in the wind. Temperatures of 17°C–24°C (63°F–75°F) and extended leaf wetness favour early blight development.

Thresholds: See the section *TOM-CAST*, on page 168.

Management Notes: Reduce early blight inoculum by following a 3- to 4-year crop rotation. Ensure transplants are healthy and free of disease. Cultivars vary in tolerance to early blight.

See Table 6–79, *Tomato Disease Control Recommendations*, on page 170.

SEPTORIA LEAF SPOT

Identification: Lower leaves become peppered with small, dark, circular spots up to 5–6 mm (¼ in.) in diameter. Spots have a dark margin with a lighter centre. Tiny, black fungal structures are visable in the centre of *Septoria* lesions. Rapid defoliation may occur if left untreated.

Development: Plants are most susceptible after fruit set. Septoria leaf spot prefers warm temperatures of 20°C–25°C (68°F–77°F) and extended periods of leaf wetness caused by heavy dews or intermittent rains.

Thresholds: See the section *TOM-CAST*, on page 168.

Management Notes: Ensure disease-free seed and transplants. Rotate crops and control solanaceous weeds, such as nightshade. See Table 6–79, *Tomato Disease Control Recommendations*, on page 170.

BACTERIAL SPOT AND BACTERIAL SPECK

Identification: It can be difficult to distinguish between these two diseases. Small, dark lesions develop on the leaves. The infected tissue of either disease may exhibit a yellow halo. Lesions also occur on stems and flower buds. Severe infections may cause defoliation.

Bacterial spot–infected fruit develop small, raised, dark spots. Lesions may have a greasy looking white halo, similar to bacterial canker. Spots increase to 4–6 mm (¼ in.) in diameter and develop brown, corky centres.

Bacterial speck lesions appear on green fruit. Specks are small (<2 mm in diameter), black, slightly raised and are often surrounded by a narrow, green-to-yellow halo. Speck lesions are usually superficial and can be scraped off. Red fruit have a lower pH and are not susceptible to infection. However, existing lesions remain after ripening.

Development: Bacterial spot prefers warm temperatures of 24°C–30°C (75°F–86°F). Bacterial speck favours cooler weather — 18°C–24°C (64°F–75°F). Abundant rainfall and high humidity aid infection of both dieseases.

Thresholds: None established. Tolerance for either disease is low in fresh market or processing tomatoes for wholepack due to marketability and peeling issues.

Management Notes: All tomato seed should be disinfected using acid or chlorine treatment. Do not plant diseased transplants. Copper fungicides may be effective in slowing bacterial spot development, **but only if applied early and often**. Bacterial speck populations in Ontario show resistance to copper. See Table 6–79, *Tomato Disease Control Recommendations*, on page 170.

> ***Note:*** Avoid working in fields when foliage is wet. Wash machinery with a high-pressure hose after working in contaminated fields. If possible, schedule irrigation for the morning to allow the foliage ample drying time before nightfall.

BACTERIAL CANKER

Identification: Early (systemic) infections from seed or seedlings are of greatest concern. They cause the plant to wilt, often on only one side. Streaking or open cankers may appear on the stems and a light, reddish-brown discolouration may be seen in the vascular tissue, just above the soil line.

The more common, and less severe, secondary infections show up later in the season. Leaves develop brown-to-

Table 6–79.
Tomato Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Bacterial Leaf Spot						
chlorothalonil *plus* copper sufate	chloronitrile & inorganic	Bravo 500	2.8 L	1.1 L	1	Only effective if applied 7 days after transplanting and repeated at 7-day intervals until July 1. Apply more frequently under wet conditions.
		plus Kocide 101	2.25 kg	0.9 kg		
mancozeb *plus* copper	dithiocarbamate & inorganic	Dithane	1.75–2.25 kg	0.7–0.9 kg	7	Only effective if applied 7 days after transplanting and repeated at 7-day intervals until July 1. Apply more frequently under wet conditions.
		plus Kocide 101	2.2 kg	0.9 kg		
		Manzate 200 DF	1.75–2.25 kg	0.7–0.9 kg	7	Only effective if applied 7 days after transplanting and repeated at 7-day intervals until July 1. Apply more frequently under wet conditions.
		plus Kocide 101	2.2 kg	0.9 kg		
copper hydroxide	inorganic	Parasol WP	2.25 kg	0.9 kg	1	Should be combined with 1.75–2.25 kg/ha mancozeb. (7 days)
Anthracnose, Early Blight, Late Blight						
captan	phthalimide	Maestro 75 DF	3.0–4.5 kg	1.2–1.8 kg	2	Anthracnose only.
		Supra Captan 80 WDG	2.75–4.25 kg	1.1–1.7 kg	2	Anthracnose only. Use high rate on mature plants.
chlorothalonil	chloronitrile	Bravo 500	2.4–4.0 L	0.96–1.6 L	1	Under heavy disease pressure, use higher rate.
mancozeb	dithiocarbamate	Dithane F-45	1.8–5.5 kg	0.7–2.2 kg	7	Aerial application permitted.
		Manzate 200 DF	1.75–3.25 kg	0.7–1.3 kg	7	
		Penncozeb 80 WP	1.1–3.25 kg	0.4–1.3 kg	7	
metiram	dithiocarbamate	Polyram DF	2.25–3.25 kg	0.9–1.3 kg	7	Low rate for early and late blight; high rate for anthracnose.
azoxystrobin	strobilurin	Quadris	300–500 mL	120–200 mL	1	Maximum 3 applications/yr. Do not apply for 21 days after transplanting. Do not apply for 6 days before or after using metribuzin.
pyraclostrobin	strobilurin	Cabrio EG	0.56–1 kg	0.22–0.4 kg	0	Use high rate for late blight. Maximum 6 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
boscalid	anilid	Lance WDG	175–315 g	70–126 g	0	Early blight. Use 420 g/ha (168 g/ac) for grey mould. Maximum 5 applications/yr. Do not make more than 2 applications before rotating to a different fungicide group.
Septoria Leaf Spot						
chlorothalonil	chloronitrile	Bravo 500	2.4–4.0 L	0.96–1.6 L	1	
captan	phthalimide	Maestro 75 DF	3.0–4.5 kg	1.2–1.8 kg	2	Use high rate on mature plants.
		Supra Captan 80 WDG	2.75–4.25 kg	1.1–1.7 kg	2	Use high rate on mature plants.
metiram	dithiocarbamate	Polyram DF	3.25 kg	1.3 kg	7	

[1] DHI = Days to Harvest Interval.

black margins with a thin, yellow border. Leaflet edges usually curl upwards.

Infected fruit may develop "bird's-eye" spots. These small lesions with light brown centres are usually surrounded by a greasy white halo.

Development: Warm, wet weather conditions with temperatures of 24°C–32°C (75°F–90°F) favour the spread of this disease.

Management Notes: Use disease-free or disinfected seed and disease-free transplants. Copper fungicides may slow canker development. See the section *Bacterial Disease Control With Copper Fungicides*, on page 171. See also Table 6–79, *Tomato Disease Control Recommendations*, above.

LATE BLIGHT

Identification: Late blight causes rapid and severe defoliation. Pale green-to-brown water-soaked spots develop on the leaves. Lesions enlarge rapidly and become brown

Bacterial Disease Control With Copper Fungicides

In the greenhouse, apply 4–5 applications of Kocide 101 at 0.9 kg/ac (2.25 kg/ha), every 5 days, starting 16–18 days after seeding. Use low water volumes — wet the foliage, but not to excessive runoff. Ensure foliage is dry when shipping plants.

In the field, apply a copper spray (with Bravo) within 7 days of transplanting, within 5 days if the weather is wet (rain, dews). Repeat copper applications at 7-day intervals through to early fruit set (or until July 1). Bacterial speck populations in Ontario show resistance to copper.

to purplish-black. A grey-to-white mouldy growth may develop on the underside of infected leaves, especially under conditions of high humidity. Brownish cankers on leaf petioles and stems may girdle and kill the plant. Fruit lesions are firm, greasy, greyish-green or brown blotches.

Development: The fungus prefers temperatures from 15°C–21°C (59°F–70°F). Cool nights and warm days, with moist weather, are ideal for disease development.

Thresholds: No tolerance. This disease is easily spread and can rapidly destroy the crop.

Management Notes: Preventative fungicide sprays for early blight, septoria and anthracnose also protect against late blight. If the disease is present in the area, follow a 5–7-day fungicide schedule, using fungicides recommended for late blight control. For more information about management practices for reducing late blight, see the section *Late Blight*, on page 134.

See also Table 6–79, *Tomato Disease Control Recommendations*, on page 170.

VERTICILLIUM WILT

Identification: Yellow, V-shaped lesions develop on the lower leaves. Symptoms often appear only on one side of the plant or one side of the leaf. The vascular tissue becomes brown and discoloured, causing infected plants to wilt, especially during the hot part of the day.

Development: Verticillium wilt is present all season. However, symptoms are often more severe after fruit set or during dry periods. The presence of plant parasitic nematodes may further aggravate verticillium wilt.

Thresholds: Soil *Verticillium* and root lesion nematode counts, available from the Pest Diagnostic Lab, University of Guelph, will determine the need for control measures. See Appendix H, *Diagnostic Services*, on page 195.

Management Notes: Follow a 4–6-year crop rotation. Do not rotate with related crops, strawberries or raspberries. Keep fields clean of host weeds such as nightshades. Cultivars tolerant to verticillium wilt are available. Soil fumigation may be required if *Verticillium* and nematode counts are high. See the section *Nematodes*, on page 57.

VIRUSES (CUCUMBER MOSAIC, TOMATO MOSAIC, STREAK, TOMATO SPOTTED WILT)

Identification: Symptoms vary between viruses, cultivars and conditions. Interaction between viruses may occur, complicating visual diagnosis.

Period of Activity: Cucumber mosaic is spread by aphids. Tomato spotted wilt is vectored by thrips. The presence of these diseases usually follows periods of high aphid/thrips activity. Tomato mosaic and the streak viruses are spread mechanically.

Management Notes: Control weed hosts in and around the field. Milkweed, ground cherry, pokeweed, chickweed and mother-wort are alternative hosts to the cucumber mosaic virus. See the section *Aphids*, on page 54.

Insects

CUTWORMS, TARNISHED PLANT BUG, WIREWORM, APHIDS

For identification and management information on these common vegetable insects affecting tomatoes, see the section *General Insects and Diseases of Vegetable Crops*, on page 54, Table 6–80, *Tomato — Aphid and Colorado Potato Beetle Control Recommendations*, on page and Table 6–81, *Tomato Insect Control Recommendations*, on page 174.

COLORADO POTATO BEETLE

Identification: Adults are orange with 10 black stripes on the wings. Larvae are red-to-orange with two rows of black spots along their sides.

Period of Activity: Feeding damage is mainly a concern early in the season when plants are small.

Thresholds: 0.5 adults or larvae per plant in the first 2 weeks after transplanting or 1 adult or larvae per plant later in the season.

Table 6–80.
Tomato — Aphid and Colorado Potato Beetle Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Aphids						
diazinon[2]	organophosphate	Diazinon 50 W	1.0–1.75 kg	0.4–0.7 kg	1	
		Diazinon 500 E	1.1–1.7 L	0.4–0.68 L	1	
		DZN 600 EW	0.915–1.4 L	0.37–0.56 L	1	
dimethoate	organophosphate	Cygon 480	0.5–1.1 L	0.2–0.44 L	7	
		Lagon 480	0.5–1.0 L	0.2–0.44 L	7	
malathion[2]	organophosphate	Malathion 25 W	2.75–4.25 kg	1.1–1.7 kg	3	
		Malathion 500 E	1.5–2 L	0.6–0.8 L	3	Not effective below 18°C (64°F).
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50 W	1.1–2.25 kg	0.44–0.9 kg	2	
methomyl	carbamate	Lannate	270–540 g	109–218 g	1	Minimum period for re-entry is 24 hr.
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of water	0.48 kg in 800 L of water	90	Based on 14,000 plants/ha. Transplanting water treatment only.
acetamiprid	chloronicotinyl	Assail 70 WP	56–86 g	22.4–34.4 g	7	Maximum 4 applications/yr. Alternate applications with other insecticide families.
Colorado Potato Beetle						
Transplant treatment						
imidacloprid	chloronicotinyl	Admire 240 F	7–10 mL per 100 m of row	2–3 mL per 100 ft of row		Applications can be made as a drench in the transplanting water or through application equipment set up exclusively to apply Admire. Consult label for details. Use only ONE application where CPB populations are high.
			0.46–1.3 L	0.19–0.52 L		
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of transplant water	0.48 kg in 800 L of water	90	Based on 14,000 plants/ha. ***Caution:*** Temporary plant damage may occur on light sandy soils or if the rate used is too high.
Foliar treatment						
azinphos-methyl	organophosphate	Guthion Soiupak	850 g	340 g	7	7 days between applications. Maximum 4 applications/yr. 48-hr re-entry period.
		APM 50 W	850 g	340 g	2	
		Sniper 50 W	850 g	340 g	2	
permethrin	pyrethroid	Pounce	180–260 mL	72–105 mL	1	
cypermethrin	pyrethroid	Cymbush 250 EC	140 mL	56 mL	3	
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83–125 mL	33–50 mL	7	Use the higher rate for larger instars or higher populations of larvae. 24-hr re-entry period.
Bacillus thuringiensis	microbial	Novodor	4.0–8.0 L	1.6–3.2 L	0	Field scouting is essential for timing of sprays.
imidacloprid	chloronicotinyl	Admire 240 F	200 mL	80 mL	7	Maximum 2 foliar spray applications at least 5 days apart may be made per year. Do not make a foliar application following a soil application of Admire in the same crop. 24-hr re-entry period.
acetamiprid	chloronicotinyl	Assail 70 WP	40–80 g	16–32 g	7	Maximum 4 applications/yr. Alternate applications with other insecticide families.
spinosad	naturalyte	Success	83 mL	33 mL	1	Use only on small larvae and low infestations. Maximum 3 applications/yr.
deltamethrin	pyrethroid	Decis 5 EC	100–150 mL	40–60 mL	3	Maximum 3 applications/yr.

[1] Days to Harvest Interval.
[2] Control of aphids with diazinon and malathion has been inconsistent in many areas.

Management Notes: Rotate crops and avoid planting tomatoes adjacent to beetle overwintering sites (previous year's tomato, eggplant or potato fields). Chemical controls are most effective when applied to small larvae. For more information, see the section *Colorado Potato Beetle*, on page 137.

See Table 6–80, *Tomato — Aphid and Colorado Potato Beetle Control Recommendations*, above.

Warning

In a number of counties and regions, Colorado potato beetles have developed a strong resistance to a number of insecticides. To slow development of further resistance, it is essential to rotate between chemical groups each time a spray is applied.

TOMATO HORNWORM

The tomato hornworm is a large, pale green-to-brown caterpillar. Mature larvae measure 8 cm (3.5 in.) in length. The hornworm has eight V-shaped markings down each side and a prominent spike (horn) on its rear end. The hornworm feeds on the leaves and new stems of tomato plants. Occasionally it will also feed on green fruit.

If thresholds exceed one larvae per 30 plants, apply one of the products listed in Table 6–81, *Tomato Insect Control Recommendations*, on page 174.

CABBAGE LOOPER

The cabbage looper is a sporadic pest of tomatoes. Use a spray threshold of 15 larvae per 30 plants. For complete identification and management information, see the section *Cabbage Looper*, on page 88. Also see Table 6–81, *Tomato Insect Control Recommendations*, on page 174.

SAP BEETLES

Sap beetles are attracted to the smell of damaged or rotting fruit. Make roadways in the field at suitable intervals to allow for the movement of farm vehicles. Minimize crushing and squashing of fruit at picking time.

For processing crops, harvest as close as possible to time of delivery to the factory. If loaded wagons are not delivered immediately, leave them exposed to air circulation.

Bird Management

Ring-billed gull feeding damage on tomato fruits results in reduced yields and quality, as well as increased sorting costs. Overall population control is not feasible. However, growers wishing to protect areas within a field can obtain a licence to shoot gulls. Early gull detection and control are important. For a permit, call the Enforcement Coordinator, Canadian Wildlife Service, Environment Canada, (905) 336-6410.

Physiological Disorders

Blossom-End Rot (BER)

Blossom-end rot is a localized calcium deficiency in the blossom end of the fruit that prevents proper development. It occurs when dry soil conditions reduce the amount of water movement into the plant, thus reducing the movement of calcium to the fruit. BER is caused primarily by drought, not by a deficiency of calcium in the soil.

Side-dressing with calcium nitrate will not prevent BER if adequate moisture is not available. Foliar sprays of calcium are also ineffective. Most of the calcium is taken up and fixed in the leaves, and very little reaches the fruit. Avoid deep cultivation, which can prune roots and reduce moisture uptake. Blossom-end rot can be controlled by properly scheduled irrigation, ensuring steady movement of water and calcium into the plant. (See the section *Irrigation*, on page 44.)

Chemical Fruit Ripening

Ethephon (Ethrel) is used on processing tomatoes for uniform ripening and once-over harvest. It will also enhance ripening in the late cultivars or during late seasons. For best results, apply ethephon to healthy fields. If plants are under moisture or disease stress, avoid use of ethephon or apply it at reduced rates.

Ethephon is only effective on mature green fruits. When cutting fruit with a sharp knife, seeds should remain uninjured and protected by a gelatinous pulp. Time applications for when 5%–20% of the fruit are showing red colour development.

Good spray coverage on fruit and foliage is essential for maximum effectiveness. Use 3.75–6.4 L ethephon in 30–500 L of water/ha (1.5–2.6 L in 12–200 L of water/ac). Use the higher rates when day temperatures are below 18°C (64°F) or when plant growth is dense. Excessive rates of ethephon will cause defoliation and reduced fruit quality. Cool temperatures will delay colour development and extend the duration between treatment and harvest. Generally, fruit is ready to harvest 14–21 days after treatment.

Ethrel is not registered for use on fresh market tomatoes.

Harvest and Storage

Mature-green fresh market tomatoes may be stored at 13°C–21°C (55°F–70°F) for 1–3 weeks. Firm, ripe tomatoes should be stored at 8°C–10°C (46°F–50°F) for no more than 4–7 days. Maintain storage at a relative humidity of 90%–95%.

Table 6–81.
Tomato Insect Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	DHI[1]	Notes
Cutworms						
permethrin	pyrethroid	Pounce	180–260 mL	72–105 mL	1	
carbaryl	carbamate	Sevin XLR plus	45 mL/100-m row	14 mL/100-ft row	2	
acephate	organophosphate	Orthene 75 SP	1.2 kg in 2,000 L of water	0.48 kg in 800 L of water	90	Based on 14,000 plants/ha. Transplanting water treatment only.
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33 mL	7	Do not disturb the soil for 5 days after application. 24-hr re-entry period.
methomyl	carbamate	Lannate	270–540 g	109–218 g	1	If many large larvae (2.5–3.0 cm) are found, use the higher rate. 24-hr re-entry period.
Tarnished Plant Bug						
cyhalothrin-lambda	pyrethroid	Matador 120 EC	83 mL	33 mL	7	Minimum period for re-entry is 24 hr.
dimethoate	organophosphate	Lagon 480	0.5–1.1 L	0.2–0.44 L	7	
carbaryl	carbamate	Sevin XLR plus	5.25–6.4 L	2.1–2.6 L	2	
Hornworm						
permethrin	pyrethroid	Pounce	180–260 mL	72–105 mL	1	
carbaryl	carbamate	Sevin XLR Plus	2.5–5.25 L	1.0–2.1 L	2	
endosulfan	chlorinated cyclodiene	Thiodan 4 EC	1.5–2.75 L	0.6–1.1 L	2	
		Endosulfan 50 W	1.1–2.25 kg	0.44–0.9 kg	2	
Bacillus thuringiensis	microbial	Thuricide HPC	0.75–1.5 L	0.3–0.6 L	0	Most effective against small larvae.
		Dipel 2XDF	140–275 g	56–110 g	0	
		Biprotec CAF	0.65–1.1 L	0.26–0.44 L	0	
azinphos-methyl	organophosphate	Guthion Solupak	0.85–1.12 kg	0.34–0.45 kg	7	48-hr re-entry period. 7 days between applications. Maximum 4 applications/yr.
		APM 50 WP	0.85–1.12 kg	0.34–0.45 kg	2	
		Sniper 50 W	0.85–1.12 kg	0.34–0.45 kg	2	
Drosophila (fruit fly)						
diazinon	organophosphate	Diazinon 50 W	1–1.75 kg	0.4–0.7 kg	1	
		Diazinon 500 E	1.1–1.7 L	0.44–0.68 L	1	
		DZN 600 EW	0.915–1.4 L	0.37–0.56 L	1	
naled	organophosphate	Dibrom	1.1 L	0.44 L	4	
azinphos-methyl	organophosphate	Guthion Solupak	0.85–1.12 kg	0.34–0.45 kg	7	48-hr re-entry period. 7 days between applications. Maximum 4 applications/yr.
		APM 50 WP	0.85–1.1 kg	0.34–0.44 kg	2	
		Sniper 50 W	0.85–1.1 kg	0.34–0.44 kg	2	
Cabbage Looper						
Bacillus thuringiensis	microbial	Thuricide HPC	2.0–4.25 L	0.8–1.7 L	0	Most effective against small larvae.
		Dipel 2XDF	275–550 g	110–220 g	0	
		Biprotec CAF	1.4–2.8 L	0.56–1.12 L	0	
Grasshopper, Cricket						
azinphos-methyl	organophosphate	Guthion SC	2.25 L	0.9 L	4	48-hr re-entry period. 7 days between applications. Maximum 4 applications/yr.
		Guthion Solupak	1.12 kg	0.45 kg	7	

[1] Days to Harvest Interval.

VEGETABLE TRANSPLANTS

Advantages

Transplants offer a number of advantages over direct seeding for many vegetable crops in Ontario. The level of management required for successful transplant production varies with the crop type. See Table 6–82, *Relative Ease of Transplanting Vegetables*, below.

Trays

Most commercial vegetable transplants are grown in plastic trays, usually in the range of 30–288 cells per tray. Various types and sizes are available. For recommended tray sizes, see Table 6–83, *Suitable Tray Sizes for Various Vegetable Species*, right.

In general, larger cells are used for early crops. They produce a bigger, more mature transplant, resulting in earlier yields. They are also more expensive to produce. Smaller cells are used for mid-to-late season crops. They are cheaper to produce, but smaller cell volume makes water and nutrient management critical.

Tray Disinfection

For transplants grown under contract, the terms may specify that new trays be used for each crop. In other cases, growers may choose to use trays for more than one season. Trays must be thoroughly sanitized before being reused. They must also be structurally and chemically able to withstand both the disinfection treatment and another season of handling.

There are two effective options to sanitize used trays:

Solarization: Stack trays and cover them with cloth or plastic. Leave them in the greenhouse during the summer. The heat will super dry the disease organisms, while allowing some non-disease organisms to survive to act as biological control agents. Use square-celled trays, to minimize the amount of growing media left in the trays from the previous use.

Chemical Disinfectants: Wash trays individually to remove particles of growing media. After washing, dip or spray them with a solution of D.C.D. or Virkon according to manufacturer's recommendations. Chlorine bleach can also be used.

Caution: Bleach residues on the trays can damage the seedlings. Dipping bulk lots of trays into a cleaning solution has not proven successful.

Table 6–82.
Relative Ease of Transplanting Vegetables

Crop	Characteristics
Easy	
Beets, broccoli, cabbages, Brussels sprouts, chard, lettuce, tomatoes	Efficient in water absorption; rapid formation of new roots.
Moderate	
Eggplant, leeks, onions, peppers, celery, cauliflower	Young plants do not absorb water as efficiently, but new roots form quickly.
Difficult	
Muskmelons, watermelons, cucumbers, squash, sweet corn	Root system is easily injured during transplanting; resume growth slowly; require special care.

Table 6–83.
Suitable Tray Sizes for Various Vegetable Species

Crop	Tray Size	Cells /ft²	Cells /m²	Production Notes
Early-market tomatoes	24	14	151	Usually seeded in 288s or 406s and transplanted to large tray at first true leaf.
	38	23	248	
	50	31	334	
Mid-to-late season tomatoes	128	78	840	Direct seeded in tray.
	288	175	1,884	
Processing tomatoes	200	122	1,313	According to processor specifications.
	288	175	1,884	
	406			
Early peppers	50	31	334	Transplant seedlings or direct seed in tray.
	72	47	506	
Mid-to-late season peppers	128	78	840	Direct seed in tray.
	200	122	1,313	
Early cole crops	72	47	506	Direct seed in tray.
	98			
Mid-to-late season cole crops	128	78	840	Direct seed in tray.
	200	122	1,313	
Cucumbers, melons, squash	24	14	151	Direct seed in tray. Do not allow plants to elongate in the greenhouse.
	128	78	840	
Cooking onions	200	122	1,313	Direct seed in tray; seedlings should be clipped several times to produce a stocky transplant.
	288	175	1,884	
	338			

Media

Growing media must be:

- sterile (free of insects, pathogens, nematodes, weed seeds)
- uniform

Table 6–84.
Vegetable Transplant Requirements

Vegetable	Seed Required for 10,000 Transplants g (oz)	Seeding Depth cm (in.)	Germination Temperature °C (°F)[1]			Days to Germination[2]	Optimum Growing Temperature °C (°F)		pH Tolerance	Time (weeks)
			Min	Opt	Max		Day	Night		
Broccoli	57 (2)	0.6 (¼)		29 (84)		4	16–21 (61–70)	10–16 (50–61)	6.0–6.8	4–7
Brussels sprouts	57 (2)	0.6 (¼)		27 (81)		5	16–21 (61–70)	10–16 (50–61)	5.5–6.8	4–7
Cabbages	57 (2)	0.6 (¼)	7 (45)	29 (84)	35 (95)	4	16–21 (61–70)	10–16 (50–61)	6.0–6.8	4–7
Cauliflower	57 (2)	0.6 (¼)	7 (45)	27 (81)	29 (84)	5	16–21 (61–70)	10–16 (50–61)	6.0–6.8	4–7
Celery	28 (1)	0.15–0.3 (⅛)	16 (61)	21[3] (70)	21 (70)	7	18–24 (64–75)	16–18 (61–64)	6.0–6.8	10–12
Cucumbers	567 (20)	1.3 (½)	16 (61)	35 (95)	35 (95)	3	21–24 (70–75)	16–18 (61–64)	5.5–6.8	2–4
Eggplant	113 (4)	0.6 (¼)	24 (75)	29 (84)	32 (90)	5	21–27 (70–81)	18–21 (64–70)	5.5–6.8	5–7
Lettuce	28 (1)	0.3 (⅛)	4.5 (40)	24 (75)	27 (81)	2	13–18 (55–64)	10–13 (50–55)	6.0–6.8	4
Muskmelons	567 (20)	1.3 (½)	24 (75)	32 (90)	35 (95)	3	21–24 (70–75)	16–18 (61–64)	6.0–6.8	3–5
Onions	85 (3)	0.6 (¼)	10 (50)	24 (75)	35 (95)	4	16–18 (61–64)	8–15 (46–59)	6.0–6.8	8–12
Peppers	198 (7)	0.6 (¼)	18 (64)	29 (84)	35 (95)	8	18–24 (64–75)	15–18 (59–64)	5.5–6.8	5–9
Squash	1,475 (52)	1.3–1.9 (½-¾)	21 (70)	35 (95)	35 (95)	3	21–24 (70–75)	16–18 (61–64)	5.5–6.8	2–4
Tomatoes	85 (3)	0.6 (¼)	16 (61)	29 (84)	29 (84)	5	18–24 (64–75)	15–18 (59–64)	5.5–6.8	5–8
Watermelons	1,475 (52)	1.3–1.9 (½-¾)	21 (70)	35 (95)	35 (95)	3	21–27 (70–81)	18–21 (64–70)	5.0–6.8	2–4

[1] Germination may be possible for many vegetables at much lower or higher temperatures, but percentage, speed and uniformity of germination will suffer.
[2] Under optimum germination temperatures. Primed seed will germinate faster than unprimed seed under most conditions.
[3] Daily fluctuation to 16°C (61°F) or lower at night is essential.

- well-drained
- lightweight
- convenient for storage and handling
- non-crusting
- able to hold water well
- free of large pieces of bark or twigs

Many commercially prepared soil-less mixtures meet these criteria. The commercial mixtures generally contain peat moss, perlite, vermiculite and a wetting agent. Some also contain fertilizer (nutrient charge). The fertilizer content of different mixtures may vary greatly. It is important to know the nutrient content of the growing media in order to manage the fertilizer program. Avoid mixtures containing slow-release fertilizer or high nutrient charges. They can restrict the flexibility of a fertilizer program.

Seeding and Germination

Vegetable transplants are generally sown one seed per cell, usually at a depth of about twice their diameter. See Table 6–84, *Vegetable Transplant Requirements*, above, for information on seed, temperature, pH and time required for producing various types of vegetable transplants.

Aim for quick, uniform germination. Best results can be obtained by:

- watering trays with warm water (27°C–28°C or 81°F–82°F) immediately after seeding

Table 6–85.
Vegetable Transplants — Acceptable Ranges of Water Quality and Correction Methods

Factor	Range	Correction
pH	5.5–6.5	Acid can be used to lower the pH.
Bicarbonate level	60–100 ppm	Acid can be used to lower the bicarbonate reading. Every 60 ppm of bicarbonate needs 7 L of phosphoric acid (85%)[1] or nitric acid (67%)[2] per 100,000 L of water.
EC (Electrical conductivity)	<0.6 mmho/cm in straight water 1.0–2.0 mmho/cm with fertilizer added	The fertilizer program can be adjusted to maintain a safe EC.
Nitrate levels	Normally less than 20 ppm	Adjust the fertilizer program accordingly.
Sulfates	Normally 150–250 ppm	
Chlorides	Normally 20–400 ppm	

[1] Use no more than 7 L of phosphoric acid per 100,000 L of water to avoid crop problems (stretching). Use nitric acid for neutralizing more than 60 ppm bicarbonate.
[2] Each 7 L of nitric acid will contribute 14 ppm of nitrate nitrogen to the irrigation water.

- placing trays in a germination chamber, maintained at the optimum temperature for that crop
- moving trays out of the germination chamber as soon as the seed coat has cracked and the shoot begins to emerge

Growth and Development

It is difficult to raise multiple crops within the same greenhouse if they have different environmental requirements (temperature, ventilation, light, water, fertility). If possible, grow crops with dissimilar requirements in different areas of the greenhouse where they can be managed as required.

Temperature

Vegetable crops vary in their response to temperature. The optimum day and night growing temperatures for a number of crops are listed in Table 6–84, *Vegetable Transplant Requirements*, on page 176.

Warm-season vegetable crops such as tomatoes, peppers, eggplant and vine crops are susceptible to chilling injury when the transplants are exposed to temperatures above freezing, but below 10°C (50°F) for an extended period of time. Chilling causes stunting of growth and can have long-lasting effects on field establishment and fruit set.

Height Control

Excessive stem elongation can be caused by low light conditions as well as excessive heat, fertilizer or water. "Pillowing" is uneven growth that results from differences in air circulation and watering between cells within trays.

Control plant height by managing the day/night temperature fluctuations in the greenhouse. Night temperatures that exceed day temperatures reduce stem elongation. Adjusting morning temperatures to 4–5 degrees Centigrade (7–9 degrees Fahrenheit) lower than the nighttime temperature will give good height control. Avoid chilling temperatures with warm-season vegetable crops.

Restricting phosphate can also effectively restrain transplant growth in the greenhouse. Excessive phosphate reductions may result in slower field establishment after transplanting.

Watering

Water Quality

Complete a detailed water analysis prior to the growing season. The greenhouse fertilizer program may have to be adjusted according to the pH, bicarbonate level and nutrient content of the water supply. See Table 6–85, *Vegetable Transplants — Acceptable Ranges of Water Quality and Correction Methods*, above.

If high-quality water is not available, obtain an alternative water supply.

Watering Transplants

Plug transplants should be watered thoroughly in the morning and "spot watered" as necessary in the afternoon. Avoid watering late in the day, as disease problems increase when plants remain wet overnight. Use chlorinated water if possible. Disease organisms can be present in surface or wellwater sources. Water should be in the 15°C–20°C (59°F–68°F) range to prevent shocking the plants.

The amount and frequency of watering will vary depending on cell type, growing media, greenhouse ventilation

Table 6–86.
Analysis for Various Soluble Fertilizers

Fertilizer Analysis	Rate for 100 ppm N (g/100 L of water)	Parts per Million			EC mmho/cm[1]
		N	P	K	
20-20-20	50	100	43	83	0.40
20-10-20	50	100	21	83	0.60
20-8-20	50	100	17	83	0.75
17-5-19	59	100	12	92	1.00
15-5-15	67	100	14	83	0.70
14-0-14	71	100	0	83	0.85

[1] Electrical conductivity of a 100 ppm solution in micromhos. The EC values were determined with a conductivity meter using distilled water. The EC values obtained will vary depending on the background EC of the water source.

and weather conditions. **Water thoroughly and moisten the entire plug, to promote root growth to the bottom of the plug.** Allow the plug to dry down before watering, but do not let the plant wilt severely.

Fertility

Vegetable transplants are usually fertilized with soluble fertilizer, applied in the irrigation water. See Table 6–86, *Analysis for Various Soluble Fertilizers*, above, for a list of fertilizers commonly used in transplant production. Use fertilizers that supply most of the nitrogen in nitrate form. Avoid fertilizers with a high concentration of urea.

A high concentration of phosphate (P_2O_5) may promote excessive seedling elongation. Use a fertilizer with a low-to-medium phosphate concentration, or use a fertilizer with no phosphate for most feedings and apply a high-phosphate fertilizer once every four or five feedings to promote growth. Do not withhold phosphate completely, as this will delay field establishment.

Vegetable crops vary in their response to fertilizer. The feeding program must be modified for different crops. Adjust the fertilizer program based on the nutrient content of the growing media, the water analysis and the cell size (larger cells require less fertilizer). See Table 6–87, *Vegetable Transplants Fertility Guidelines*, right.

Toxicities and Deficiencies

Nutrient deficiencies are more common than nutrient toxicities. Many growers are very cautious about overfertilizing for fear of "burning" the roots or stems.

Phosphorus-deficient transplants show very definite purple colouration along the stem and underside of leaves. Plants that have too little nitrogen will have pale-green foliage. Too much nitrogen will result in very white stems and dark-green leaves.

Table 6–87.
Vegetable Transplants Fertility Guidelines

Crop	Fertility Guidelines
Tomatoes	Very responsive to fertilizer, excess fertility will reduce transplant quality. If feeding at every watering, use a fertilizer concentration of 50–100 ppm N, depending on the stage of development. There may be some advantage to feeding less often at a higher concentration.
Peppers	Require more fertilizer than tomatoes. If feeding at every watering, use approximately 100 ppm N and increase the concentration if feeding less often.
Cole crops	Do not require as much fertilizer as other crops. One application per week of 100–150 ppm N should be sufficient under most conditions.
Vine crops	Have a relatively short growing cycle compared to other crops. Use 100–150 ppm N at weekly intervals for a total of 2–4 applications.

Hardening-Off

Prepare transplants for the harsher environment of the field by hardening them off. This is especially important for early-season plantings.

Reduce greenhouse temperatures to harden-off transplants. Warm-season crops should not be hardened at temperatures below 13°C (55°F). Cool-season crops can be hardened at lower temperatures. Certain cole crops can be susceptible to "bolting" or "buttoning" in the field if the transplants are exposed to prolonged temperatures below 10°C (50°F).

Slightly reduce water, as part of the hardening process. Do not let plants wilt excessively. They must be actively growing for good field establishment. Increasing air movement around the transplants also assists in the hardening process.

If there is no risk of frost, consider holding plants outside for several days before field planting. This allows them to become acclimated to field conditions while they are still in their trays. Select a location that is exposed to full sunlight but is protected from drying winds. Check plants regularly and water as required.

Do not harden off plants by withholding fertilizer, as this can result in nutrient deficiencies and delay field establishment. Slow-to-establish plants are more susceptible to insects, diseases and poor growing conditions.

Storage of Plug Transplants

Research has shown that, if properly stored, tomato transplants can be held for up to 2 weeks with little reduction in plant stand or vigour. Either return them to the greenhouse or store them outside. Storage in an enclosed trailer or barn for more than 1 or 2 days will result in very soft, elongated plants.

During storage:

- Elevate the racks to prevent root growth through the bottom of the plugs.
- Bring the plants inside if there is a risk of frost.
- Fertilize if planting is delayed by more than 5–7 days. A low-phosphorus, soluble fertilizer such as 20-8-20 or 20-10-20, applied in the irrigation water according to manufacturers directions, is suitable for this purpose.

Disease Management

The primary means of controlling diseases on vegetable transplants is by seed treatment, sanitation and by managing the greenhouse environment to suppress disease development.

Seed treatment methods, such as hot-water, acid or chlorine, may help reduce bacterial and fungal pathogens on the seed. It is particularly important for the control of bacterial diseases of tomatoes, peppers and cole crops. See the section *Common Treatments for Vegetable Seed*, right.

All vegetable seed should be treated with a fungicide to help prevent seed decay and damping-off. See the individual commodity sections for a list of recommended chemical seed treatments.

Certain transplant or greenhouse crops should not be raised in close proximity, as one may act as a source of disease or as an alternate host for insect vectors. Avoid growing tomato transplants close to greenhouses used for flowers or greenhouse cucumbers. Pepper and tomato transplants should not be raised in the same greenhouse complex.

BACTERIAL SPOT

Bacterial spot is a serious disease of peppers and tomatoes. All seed should be disinfected using acid or chlorine treatment. A greenhouse spray program with Kocide 101 can greatly reduce the field infection rate later in the season. Apply four to five applications of Kocide 101 at 0.9 kg/ac (2.25 kg/ha), every 5 days, starting 2½ weeks after seeding. Use low water volumes — wet the foliage, but not to excessive runoff. Ensure foliage is dry when shipping plants.

Common Treatments for Vegetable Seed

Hot-Water Treatment

1. Place seed in a large cheesecloth bag; the bag should be no more than half full. Place bags of seed in a large container filled with warm water.
2. Stir the water and bags of seed continually to secure rapid penetration of heat to maintain uniform temperature in the seed lot. Be sure to use an accurate thermometer.

CABBAGES, BROCCOLI, BRUSSELS SPROUTS, PEPPERS AND EGGPLANT
Soak seed for 25 minutes in water maintained at 50°C (122°F). Spread seed out to dry.

CAULIFLOWER, KOHLRABI, KALE AND SUMMER TURNIP
Treat seed as above but for 15 minutes.

CELERY
Treat seed at 48°C (118°F) for 30 minutes.

TOMATOES
Tomato seed can be treated at 54°C (129°F) for 25 minutes. Plant seeds within a few days of treating.

Acid Treatment

Tomato seed can also be treated by soaking dry seed in a 0.1 M hydrochloric acid solution. Submerse the dry seed for 1 hour using a 9:1 v/v ratio (9 parts solution:1 part seed). Agitate frequently to separate the seeds. Seeds can be dried without further rinsing.

0.1 M hydrochloric acid solution is commercially available; it can also be prepared by mixing 1 part muriatic acid (31.45% HCL) with 100 parts water.

Chlorine Treatment

Chlorine seed treatment is another alternative for treating tomatoes, peppers and vine crop seed. Prepare a solution of 1 part household bleach (about 5% sodium hypochlorite) to 4 parts water. Use 835 mL of solution per 100 g of seed. A non-ionic surfactant may be added at 1.35 mL/L of solution. Agitate seeds in this solution for 1 minute. Rinse seed thoroughly in running water for 5 minutes, then spread seed out to dry. Prepare a fresh solution for each batch of seed.

Fungicides registered for use on greenhouse vegetables are listed in Table 6–88, *Vegetable Transplant Greenhouse Disease Control Recommendations*, on page 180.

Table 6–88.
Vegetable Transplant Greenhouse Disease Control Recommendations

Common Name	Group	Trade Name	Rate per Hectare	Rate per Acre	Notes
Damping-Off, Fungus Root Rot					
captan	phthalamide	Maestro 75 DF	1.5 kg/1,000 L of water Apply 50–85 L of solution per 100 m^2 (1,076 ft^2)		Crucifers, eggplant, peppers, tomatoes, celery. Soil drench treatment.
		Supra Captan 80 WDG	1.25 kg/1,000 L of water Apply 50–85 L of solution per 100 m^2 (1,076 ft^2)		Crucifers, eggplant, peppers, tomatoes, celery. Soil drench treatment.
oxine benzoate	dithiocarbamate	No-Damp	10 mL/L of water		Vegetable seedlings. Damping-off. Soil treatment.
Bacterial Spot					
cupric hydroxide	inorganic	Kocide 101	2.25 kg/ha	0.9 kg/ac	Tomatoes, peppers. Bacterial spot. Apply every 5 days, for 5 applications over a 4-week period, starting 2.5 weeks after seeding. Apply in low water volumes.
Botrytis Grey Mould					
ferbam	dithiocarbamate	Ferbam 76 WDG	2 kg/1,000 L of water		Lettuce only. Spray 76% solution to wet plants only.

For more information on managing disease, see the section *General Insects and Diseases of Vegetable Crops*, on page 54.

Insect Management

Insects such as aphids and thrips may transmit disease into and within the greenhouse. Fungus gnats and shore flies can cause damage by larval feeding on seedling roots and by spreading damping-off organisms.

Monitor for thrips and aphids. Hang blue sticky traps close to the seedling canopy. Indicator plants (such as potted petunia for tomato spotted wilt virus) can be placed at the ends of the greenhouse.

Herbicide Injury

Greenhouses should be equipped with a sprayer dedicated to herbicides only and a separate sprayer for fungicides and insecticides. Contamination may cause serious damage to greenhouse plants.

Avoid spraying weeds outside the greenhouse during the growing season. Herbicide mist or fumes may drift or be drawn into the greenhouse. Transplant trays left outside on headlands may be inadvertently sprayed. Trays stored near herbicides can also absorb fumes. Once contaminated, trays cannot be cleaned effectively.

7. Appendices

Appendix A.
Pesticides Used on Vegetable Crops in Ontario

Use Codes

a – acaricide
b – bactericide
f – fungicide
h – herbicide
i – insecticide
m – miticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

Formulation Codes

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
1,3 dichlorpropene	*See TELONE II*						
1,3 dichlorpropene/ chloropicrin	*See TELONE C-17*						
acephate	*See ORTHENE*						
acetamiprid	*See ASSAIL*						
ACROBAT MZ	dimethomorph/ mancozeb	f	EC	9/ 60	2	potatoes	ENG
ACTIVOL	gibberellic acid	pgr		0.92 g/tablet	6	rhubarb	NOR
ADMIRE 240 F	imidacloprid	i	Fl	240 g/L	5	Brussels sprouts, eggplant, lettuce, potatoes, tomatoes	BCZ
AGROX B-2	diazinon + captan	s	D	11/33.5	2	beans, peas, sweet corn	NOR
AGROX CD	diazinon + captan	s	D	15/15	2	beans, peas, sweet corn	NOR
ALIETTE WDG	fosetyl-al	f	WG	80	5	lettuce, onions, broccoli, bok choy	BCZ
ALLEGIANCE FL	metalaxyl	s	Fl	317 g/L	3	beans, peas, sugarbeets, sweet corn	GUS
APM 50 W	azinphos methyl	i	WP	50	5	cole crops, potatoes, tomatoes	NOR
APRON FL	metalaxyl	s	Fl	317 g/L	3	beans, peas, sugarbeets, sweet corn	GUS
APRON XL LS	metalaxyl-M	s	Li	33.3	2	beans, table beets, carrots, onions, peas, spinach, sweet corn, sugarbeets	SYN
ASSAIL 70 WP	acetamiprid	i	WP	70	3	celery, cole crops, lettuce, endive, parsley, spinach, swiss chard, leafy greens (see label), rhubarb, specialty vegetables, tomatoes	DUQ
azinphos-methyl	*See APM, GUTHION, SNIPER*						
azoxystrobin	*See QUADRIS*						
Bacillus thuringiensis	*See NOVODOR, DIPEL, THURICIDE, BIOPROTEC*						
BASAMID GRANULAR	dazomet	n	Gr	98	2	non-crop areas	BAZ
BIOPROTEC CAF	Bacillus thuringiensis	i	Su	11,400 IU/mg	3	beans (snap), cole crops, herbs, sweet corn, tomatoes	AEF
BOTRAN 75 W	dichloran	f	WP	75	3	garlic, lettuce, beans	GOW
boscalid	*See LANCE*						
BRAVO 500	chlorothalonil	f	Fl	500 g/L	3	cole crops, carrots, celery, cucurbits (vine crops), onions, parsnips, potatoes, sweet corn, tomatoes	SYN
BUSAN 1020	metam sodium	n	Gr	33	3	non-crop areas	BUL
CABRIO EG	pyraclostrobin	f	EC	20	3	beets (table), carrots, cucurbits (vine crops), eggplant, horseradish, onions, peppers, rutabaga, tomatoes	BAZ
captan	*See CAPTAN, MAESTRO, SUPRA CAPTAN*						
CAPTAN FL	captan	s	Fl	30	3	beans, peas, sweet corn	NOR

Appendix A.
Pesticides Used on Vegetable Crops in Ontario (Continued)

Use Codes

a – acaricide
b – bactericide
f – fungicide
h – herbicide
i – insecticide
m – miticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

Formulation Codes

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
EC = emulsifiable concentrate
EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
carbaryl	*See SEVIN XLR*						
carbathiin-thiram	*See PRO-GRO, VITAFLO*						
carbofuran	*See FURADAN*						
chlorothalonil	*See BRAVO*						
chlorpyrifos	*See LORSBAN, PYRIFOS, PYRINEX*						
CITATION 75 WP	cyromazine	i	WP	75	2	celery	SYN
clothianadin	*See PONCHO*						
COPPER 53 W	copper sulfate	f	WP	53	2	table beets, cole crops, celery, cucurbits (vine crops), potatoes, peppers	UAG
copper hydroxide	*See PARASOL, KOCIDE 101 DF*						
copper oxychloride	*See COPPER SPRAY*						
COPPER SPRAY	copper oxychloride	f	WP	50	3	celery, cucurbits (vine crops), potatoes	UAG
copper sulfate	*See COPPER 53W*						
COUNTER 15 G	TERBUFOS	i	Gr	15	5	sugarbeets	BAZ
CURZATE 60 DF	cymoxanil	f	DF	60	2	potatoes	DUQ
CYGON 480	dimethoate	i	EC	480 g/L	2	asparagus, beans, beets, cole crops, eggplant, lettuce, peas, peppers, potatoes, Chinese broccoli, Chinese cabbage, pak choy, spinach, tomatoes	BAT, CAU
cyhalothrin-lambda	*See MATADOR*						
CYMBUSH 250 EC	cypermethrin	i	EC	250 g/L	2	asparagus, broccoli, cole crops, carrots, celery, lettuce, onions, potatoes, rutabagas, sweet corn, tomatoes	SYN
cymoxanil	*See CURZATE*						
cypermethrin	*See Cymbush, Ripcord*						
cyromazine	*See GOVERNOR, CITATION*						
dazomet	*See BASAMID*						
DCT	diazinon/captan/ thiophanate-methyl	s	D	6/18/14	3	sweet corn	NOR
DECIS 5 EC	deltamethrin	i	EC	50 g/L	2	asparagus, cole crops, onions, peppers, potatoes, sweet corn, tomatoes	BCZ
deltamethrin	*See DECIS*						
DES-I-CATE	endothall	v	Li	62 g/L	2	potatoes	CRX
diazinon	*See DIAZINON, DZN*						
diazinon/captan	*See AGROX*						
DIAZINON 50	diazinon	i	WP	50	2	carrots, onions, parsnips, peppers, radishes, spinach, tomatoes	UAG
DIAZINON 500 E	diazinon	i	EC	500 g/L	2	table beets, lettuce, onions, parsnips, radishes, spinach, tomatoes	UAG
DIBROM	naled	i	EC	864 g/L	2	beans (lima), cole crops, celery, lettuce, endive, mustard greens, onions, peas, potatoes, spinach, sugarbeets, tomatoes	UAG

Appendix A.
Pesticides Used on Vegetable Crops in Ontario (Continued)

Use Codes

a – acaricide
b – bactericide
f – fungicide
h – herbicide
i – insecticide
m – miticide
n – nematicide
pgr – plant growth regulator
r – rodenticide
s – seed treatment
v – vine killing

Formulation Codes

D = dust
DC = dispersible concentrate
DF = dry flowable
DG = dry granules
DP = dry powder
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EW = water-based concentrate
Fl = flowable
Gl = gel
Gr = granular
Li = liquid
SC = soluble concentrate
SG = soluble granules
SP = soluble powder
Sn = solution
Su = suspension (flowable)
WG = wettable granules
WP = wettable powder

Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
dichloran	*See BOTRAN*						
dicofol	*See KELTHANE*						
dimethoate	*See CYGON, LAGON*						
dimethomorph/mancozeb	*See ACROBAT*						
DIPEL 2X DF	Bacilus thuringiensis	i	DF	32,000/mg	3	cole crops, herbs, lettuce, parsley, spinach, specialty vegetables, mustard greens, sweet corn, tomatoes	VAN
diquat	*See REGLONE*						
DITHANE	mancozeb	f	DG	80	3	carrots, celery, cucurbits (vine crops), dry onions, potatoes, tomatoes, sugarbeets	DWE
DITHANE F-45	mancozeb	f		37	3	potatoes, tomatoes, sugarbeets	DWE
DITHANE M-45	mancozeb	s	DG	8	3	potatoes	DWE
DZN 600 EW	diazinon	i	EW	600 g/L	3	beets, carrots, lettuce, onions, parsley, parsnips, peppers, radishes, spinach, Swiss chard, tomatoes	ENG
endosulfan	*See ENDOSULFAN, THIODAN, THIONEX*						
ENDOSULFAN 50W	endosulfan	i	WP	50	2	celery, cole crops, cucurbits (vine crops), head lettuce, spinach, eggplant, peppers, potatoes, tomatoes	UAG
endothall	*See DES-I-CATE*						
fenamidone	*See REASON*						
FERBAM 76 WDG	ferbam	f	WG	76	3	transplant lettuce	UAG
ferric phosphate	*See SLUGGO*						
fludioxonil	*See MAXIM*						
FORCE	tefluthrin	i	Gr	3	3	sweet corn	SYN
FULFILL 50 WDG	pymetrozine	i	WG	50	2	potatoes	SYN
FURADAN 480 F	carbofuran	i	Fl	480 g/L	5	peppers, sweet corn, potatoes	BCZ
GAUCHO 480	imidacloprid	s	Fl	480 g/L	5	sweet corn	GUS
GAVEL 75 DF	zoxamide/mancozeb	f	DF	75	3	potatoes	DWE
gibberellic acid	*See ACTIVOL*						
glufosinate ammonium	*See IGNITE*						
GOVERNOR 75 WP	cyromazine	s	WP	75	5	imported onion seed	SYN
GUTHION SC	azinphos-methyl	i	SC	240 g/L	5	Chinese cabbage, cucurbits (vine crops), potatoes, tomatoes	BCZ
GUTHION SOLUPAK	azinphos-methyl	i	WP	50	5	cole crops, Chinese cabbage, cucurbits (vine crops), tomatoes	BCZ
HEADLINE EC	pyraclostrobin	f	EC	250 g/L	2	potatoes, sugarbeets	BAZ
hydrogen peroxide	*See OXIDATE*						
IGNITE 15 SN	glufosinate ammonium	v	Sn	150 g/L	3	potatoes	BCZ
imidacloprid	*See ADMIRE, GAUCHO*						
IMIDAN 50 WP	phosmet	i	WP	50	3	carrots, celery	GOW
iprodione	*See ROVRAL*						

Appendix A.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
KELTHANE 50 W	dicofol	m	WP	50	2	beans, cucurbits (vine crops)	DWE
KOCIDE 101	copper hydroxide	f	WP	77	2	peppers, tomatoes, potatoes, sugarbeets, tomato and pepper transplants (in greenhouse)	GRN
KOCIDE DF	copper hydroxide	f	DF	61.4	2	peppers, potatoes	GRN
LAGON 480	dimethoate	i	EC	480 g/L	2	asparagus, beans, cole crops, eggplant, lettuce, peas, peppers, potatoes, specialty vegetables, spinach, tomatoes	UAG
LANCE WDG	boscalid	f	WP	70	5	beans (snap and lima), carrots, eggplant, lettuce, onions, peppers, potatoes, tomatoes	BAZ
LANNATE	methomyl	i	SP	90	2	beans, cole crops, head lettuce, peas, sweet corn, tomatoes	DUQ
LORSBAN 15 G	chlorpyrifos	i	Gr	15	2	onions, broccoli, Brussels sprouts, cabbage, cauliflower, rutabaga	DWE
LORSBAN 4E	chlorpyrifos	i	EC	480 g/L	2	carrots, celery, cole crops, cucumber, garlic, onions (bulb), radishes, specialty vegetables, peppers, potatoes, rutabagas, sugarbeets, sweet corn	DWE
LORSBAN 50W	chlorpyrifos	i	WP	50	2	cabbage	DWE
MAESTRO 75 DF	captan	f	DF	75	2	cucumber, tomatoes, vegetable transplants in greenhouse (crucifer, eggplant, pepper, tomatoes, celery)	TMO
MALATHION 25W	malathion	i	WP	25	3	asparagus, beets, cucurbits (vine crops), peas, spinach, tomatoes	UAG
MALATHION 500 E	malathion	i	EC	500 g/L	3	asparagus, beans, beets, celery, cucurbits (vine crops), garlic, lettuce, peas, peppers, radishes, sugarbeets, tomatoes	UAG
maleic hydrazide	*See ROYAL MH 60*						
mancozeb	*See DITHANE, TUBERSEAL, POTATO ST, PENNCOZEB, MANZATE*						
MANZATE 200 DF	mancozeb	f	DF	75	3	carrots, celery, cucumber, onions (dry), potatoes, tomatoes, sugarbeets	GRN
MATADOR 120 EC	cyhalothrin-lambda	i	EC	120 g/L	2	cole crops, garlic, head lettuce, onions, potatoes, sweet corn, tomatoes	SYN
MAXIM 480 FS	fludioxonil	s	Fl	40.3	2	sweet corn	SYN
MAXIM PSP	fludioxonil	s	DP	0.5	2	potato seed piece	SYN
metalaxyl	*See RIDOMIL, APRON, ALLEGIANCE*						
metalaxyl-M	*See RIDOMIL GOLD, APRON XL LS*						
metalaxyl/ chlorothalonil	*See RIDOMIL/BRAVO*						
metam sodium	*See BUSAN, VAPAM*						
methamidophos	*See MONITOR*						
methomyl	*See LANNATE*						
METHOXYCHLOR 240	methoxychlor	i	WP	50	3	asparagus, cucurbits (vine crops)	UAG
metiram	*See POLYRAM*						
MICROSCOPIC SULPHUR	sulphur	f	WP	92	6	rutabagas	UAG

Appendix A.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
mineral oil	*See SUPERIOR OIL*						
MONITOR 480	methamidophos	i	EC	480 g/L	5	cole crops, head lettuce, potatoes	TMO/ BCZ
myclobutanil	*See NOVA*						
naled	*See DIBROM*						
NO-DAMP	oxine benzoate	f	Li	3.2	3	vegetable seedlings in greenhouse	PLG
NOVA 40W	myclobutanil	f	WP	40	2	asparagus	DWE
NOVODOR	Bacillus thuringiensis	i	Fl	15,000/g	3	potatoes, tomatoes	VAN
ORTHENE 75 SP	acephate	i	SP	75	2	celery, cole crops, head lettuce, peppers, potatoes, sweet corn, tomatoes	TMO
oxamyl	*See VYDATE*						
OXIDATE	hydrogen peroxide	f	Li	27	5	potatoes	Biosafe
oxine benzoate	*See NO-DAMP*						
PARASOL WP	copper hydroxide	f	WP	50	3	beans, peppers, potatoes, sugarbeets, tomatoes	NUA
PENNCOZEB 80 WP	mancozeb	f	WP	80	3	carrots, celery, cucurbits (vine crops), onions, potatoes, sugarbeets, tomatoes	CRX
permethrin	*See POUNCE*						
phorate	*See THIMET*						
phosmet	*See IMIDAN*						
pirimicarb	*See PIRIMOR*						
PIRIMOR 50 DF	pirimicarb	i	DF	50	2	asparagus, celery, lettuce, peas, peppers, potatoes, spinach, sweet corn	SYN
POLYRAM 16 D	metiram	s	D	16	3	potato	BAZ
POLYRAM DF	metiram	f	DF	80	3	asparagus, carrots, celery, potatoes, tomatoes	BAZ
PONCHO	clothianadin	s				sweet corn	GUS
POTATO ST 16	mancozeb	s	D	16	3	potato	UAG
POUNCE	permethrin	i	EC	384 g/L	3	asparagus, beans, beets (table) carrots, cole crops, horseradish, lettuce, onions, peppers, peas, potatoes, radishes, rutabagas, specialty vegetables, sweet corn, tomatoes	UAG/ BCZ
PRO-GRO	carbathiin/thiram	s	D	30/50	3	onions	UNR
propamocarb/HCl/ chlorothalonil	*See TATTOO C*						
propiconazole	*See TOPAS, TILT*						
pyraclostrobin	*See CABRIO, HEADLINE*						
PYRIFOS 15 G	chlorpyrifos	i	Gr	15	3	cole crops, onions	UAG
PYRIFOS 50 W	chlorpyrifos	i	WP	50	2	cabbage	UAG
PYRINEX 480 EC	chlorpyrifos	i	EC	480 g/L	2	carrots, celery, cole crops, cucumbers, garlic, dry onions, peppers, potatoes, radish, rutabaga, specialty vegetables, sweet corn	UAG
pyrmetrozine	*See FULFILL*						

Appendix A.
Pesticides Used on Vegetable Crops in Ontario (Continued)

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WP = wettable powder

Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
QUADRIS	azoxystrobin	f	SC	250 g/L	2	potatoes, tomatoes	SYN
QUINTOZENE 75 WP	quintozene	f	WP	75	3	cole crops	PLG
REASON 500 SC	fenamidone	f	EC	500 g/L	3	potatoes	BCZ
REGLONE	diquat	v	Li	200 g/L	2	potatoes	SYN
RIDOMIL 2G	metalaxyl	f	Gr	2	2	carrots, lettuce	SYN
RIDOMIL GOLD 480 EC	metalaxyl-M	f	EC	480 g/L	2	snap bean, potatoes	SYN
RIDOMIL GOLD MZ 68 WP	metalaxyl-M + mancozeb	f	WP	6/64	2	lettuce, onions, potatoes, Belgian endive	SYN
RIDOMIL/BRAVO twin pak	metalaxyl-M/chlorothalonil	f	EC	240/500 g/L	2	potatoes	SYN
RIPCORD 400 EC	cypermethrin	i	EC	400 g/L	2	cole crops, lettuce, potatoes, sweet corn, carrots, onions	BAZ
RONILAN EG	vinclozolin	f	DF	50	2	beans, lettuce	BAZ
ROTENONE 5%	rotenone	i	WP	5	3	asparagus, cucurbits (vine crops)	***
ROVRAL	iprodione	f	WP	50	3	beans, cabbages, cauliflower, garlic, lettuce, dry onions, carrots (imported seed)	BCZ
ROYAL MH 60 SG	maleic hydrazide	pgr	SG	60	3	dry onions, potatoes	UNR
SENATOR 70 WP	thiophanate-methyl	f	WP	70	3	sugarbeets	ENG
SENATOR PSPT	thiophanate-methyl	s	D	10	6	potatoes	ENG
SEVIN XLR PLUS	carbaryl	i	Su	480 g/L	3	asparagus, beans, carrots, celery, cole crops, cucurbits (vine crops), eggplant, horseradish, lettuce, leafy greens, peppers, radishes, rutabagas, sweet corn, tomatoes, Chinese cabbage	BCZ
SLUGGO	ferric phosphate	i	bait	0.76	6	beans (snap), cole crops, peas, sweet corn	ENG
SNIPER 50 W	azinphos methyl	i	WP	50	5	potatoes, cole crops, cucurbits (vine crops), tomatoes	UAG
spinosad	*See SUCCESS*						
SUCCESS 480 SC	spinosad	i	SC	480 g/L	3	beans (snap), cole crops, lettuce, leafy greens, peppers, potatoes, radishes, rutbagas, specialty vegetables, spinach, swiss chard, sweet corn, tomatoes	DWE
sulphur	*See MICROSCOPIC SULPHUR*						
SUPERIOR OIL 70	mineral oil	a, i	Li	99	6	rutabagas	***
SUPRA CAPTAN 80 WDG	captan	f	WG	80	2	cucumbers, tomatoes, vegetable transplants in greenhouse (cole crops, eggplant, peppers, tomatoes, celery)	UAG
TATTOO C	propamocarb /HCl/ chlorothalonil	f	EC	(1:1) 375 g/L	2	potatoes	BCZ
tefluthrin	*See FORCE*						
TELONE C-17	1,3 dichloropropene chlorothalonil	n,f	Li	78/19.5	2	non-crop areas	DWE
TELONE II	1,3 dichloropropene	n	Li	94	2	non-crop areas	DWE
terbufos	*See COUNTER*						
THIMET 15 G	phorate	i	Gr	15	2	potatoes	BAZ

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WP = wettable powder

Examples of Brand Name/ Trade Name[1]	Active Ingredient/ Common Name	Use	Formulation	Guaranteed % Active Unless Stated	Ontario Schedule[2]	Crop Recommended Registrations	Company of Agent's Code
THIODAN 4 EC	endosulfan	i	EC	400 g/L	2	beans, cole crops, celery, cucurbits (vine crops), eggplant, head lettuce, peas, peppers, potatoes, rutabagas, spinach, tomatoes	BCZ
THIODAN 50 WP	endosulfan	i	WP	50	2	celery, cole crops, cucurbits (vine crops), eggplant, peppers, potatoes,	BCZ
THIONEX EC	endosulfan	i	EC	400 g/L	2	cole crops, rutabagas	UAG
thiophanate-methyl	*See SENATOR*						
THIRAM 75 WP	thiram	s	D	75	2	beans, table beets, cole crops, cucurbits (vine crops), lettuce, onions, peas, peppers, rutabagas, spinach, sweet corn, sugarbeets	GUS
THURICIDE HPC	Bacillus thuringiensis	i	Li	4,000/mg	3	celery, cole crops, lettuce, mustard greens, spinach, tomatoes	NOR
TILT 250 E	propiconazole	f	EC	250 g/L	2	sweet corn	SYN
TOPAS 250 E	propiconazole	f	EC	250 g/L	2	rutabagas, asparagus	ENG
TUBERSEAL	mancozeb	s	D	16	3	potato seed piece	NOR
VAPAM	metam sodium	h, f	Sn	380 g/L	3	preplant site preparation	UAG
vinclozolin	*See RONILAN*						
VITAFLO 280	carbathiin/thiram	s	Fl	15.59/ 13.25	3	beans, peas	GUS
VYDATE L	oxamyl	i	Li	240 g/L	5	potatoes	DUQ
ZINEB 80 W	zineb	f	WP	80	3	asparagus, carrots, celery, cole crops, lettuce, onions	UAG
zoxamide/mancozeb	*See GAVEL*						

[1] Mention of a brand or trade name in this table does not constitute a guarantee or warranty of the product by the Ontario Crop Protection Committee nor that these products are approved to the exclusion of comparable products. All trade names are capitalized.

[2] **Ontario Classification Schedule:**
Listed below are the schedules classified under the *Pesticides Act*. The majority of materials listed for vegetables are classified as Schedule 2 or 5. Consult your local pest control product supplier or, for more information, contact the Ministry of the Environment and Energy office nearest you.

Schedule 1: Restricted. Use permit only.
Schedule 2: Restricted to certified agriculturists, licensed exterminators, registered custom sprayer and permit holders.
Schedule 3: Agriculturists and consumer use.
Schedule 4: Domestic products only.
Schedule 5: Limited to application on agricultural land. Similar to Schedule 2.
Schedule 6: Similar to Schedule 4 but may be registered for agricultural/commercial use, container size 1 L or greater.

Appendix B.
Pest Control Product Companies

Code	Company/Agent	Web Site	Contact Number
****	Various manufacturers		
AEF	AEF Global Inc.	www.aefglobal.com	1-418-838-4441
BAZ	BASF Canada Inc.	www.agsolutions.ca	1-877-371-2273
BAT	Bartlett, N. M. Inc.	www.bartlett.ca	1-800-263-1287
BCZ	Bayer Crop Science	www.bayercropscience.ca	1-800-283-6847
BUL	Buckman Labs of Canada		(405) 424-4404
CRX	Atofina Canada Inc	www.atofina.com	(905) 827-9841
CAU	Cheminova Canada Inc	www.cheminova.com/	1-888-316-6260
DWE	Dow Agrosciences Canada Inc.	www.dowagro.ca	1-800-667-3852
DUQ	Dupont Canada Inc.	www.dupont.ca/ag/	1-800-667-3925
ENG	Engage Agro Corp.	www.engageagro.com	1-800-900-5487
GOW	Gowan Company	www.gowanco.com/	1-800-883-1844
GRN	Griffin L.L.C.	www.griffinllccanada.com/	(229) 242-8635
GUS	Gustafson	www.gustafson.ca/	
NOR	Norac Concepts Inc.	www.noracconcepts.com	(613) 841-2907
NUA	NuFarm Agriculture Inc.	www.nufarm.ca	1-800-868-5444
PLG	Plant Products Co. Ltd.	www.plantprod.com/	1-800-387-2449
SYN	Syngenta Crop Protection	www.syngenta.ca/	1-800-459-2422
TMO	Arvesta Corp.	www.arvesta.com	(415) 536-3480
UNR	Crompton Company	www.cromptoncorp.com	1-800-265-2157
UAG	United Agri-Products Canada Inc.	www.uap.ca	1-800-265-4624
VAN	Valent BioSciences Canada Ltd.	www.valentbiosciences.com	(905) 659-0886

Appendix C.
Ontario Ministry of the Environment Pesticides Control Offices

Region/County	Address	Telephone/Fax
Central Region Toronto, Halton, Peel, York, Durham	5775 Yonge St., 8th floor Toronto, Ontario M2M 4J1	Tel (416) 326-6700 Toll-free 1-800-810-8048 Fax (416) 325-6347
West-Central Region Haldimand-Norfolk, Niagara, Hamilton-Wentworth, Dufferin, Wellington, Waterloo, Brant	Ontario Government Building 119 King St. W., 12th floor Hamilton, Ontario L8P 4Y7	Tel (905) 521-7640 Toll-free 1-800-668-4557 Fax (905) 521-7820
Eastern Region Frontenac, Hastings, Lennox & Addington, Prince Edward, Leeds & Grenville, Prescott & Russell, Stormont/Dundas & Glengarry, Peterborough, Victoria, Northumberland, Renfrew, Ottawa-Carleton, Lanark, District of Nipissing (Townships of Airy, Murchison, Dickens, Lyell and Sabine)	133 Dalton Ave. Kingston, Ontario K7L 4X6	Tel (613) 549-4000 Toll-free 1-800-267-0974 (Eastern region only) Fax (613) 548-6908
Southwestern Region Elgin, Middlesex, Oxford, Essex, Kent, Lambton, Bruce, Grey, Huron, Perth, Simcoe	659 Exeter Rd., 2nd floor London, Ontario N6E 1L3	Tel (519) 873-5000 Toll-free 1-800-265-7672 Fax (519) 873-5020
Northern Region East Manitoulin, Nipissing, Parry Sound, Sudbury, Algoma East, Cochrane East, Haliburton, Muskoka	199 Larch St., Ste. 1101 Sudbury, Ontario P3E 5P9	Tel (705) 564-3249 Fax (705) 564-4180
Northern Region West Kenora, Rainy River, Thunder Bay, Algoma West, Cochrane West	435 James St. S., Ste. 331 Thunder Bay, Ontario P7E 6S7	Tel (807) 475-1712 Toll-free 1-800-875-7772 Fax (807) 475-1754
Standards Development Branch	Pesticides Section 40 St. Clair Ave. W., 7th floor Toronto, Ontario M4V 1M2	Tel (416) 327-5519 Fax (416) 327-2936
Approvals Branch	Pesticides Licensing 2 St. Clair Ave. W., 12A floor Toronto, Ontario M4V 1L5	Tel (416) 314-8001 Toll-free 1-800-461-6290 Fax (416) 314-8452

Appendix D.
Accredited Soil-Testing Laboratories in Ontario

The following labs are accredited to perform soil tests for pH, buffer pH, P, K, Mg and Nitrate-N on Ontario soils.

Laboratory Name	Address	Telephone/Fax/E-mail	Contact
A & L Canada Laboratories East Inc. Web site: www.al-labs-can.com	2136 Jetstream Rd. LONDON, Ont. N5V 3P5	Tel: (519) 457-2575 Fax: (519) 457-2664 E-mail: aginfo@al-labs-can.com	Mr. Greg Patterson Mr. Ian McLachlin
Accutest Laboratories Web site: www.accutestlabs.com	146 Colonnade Rd., Unit #8 NEPEAN, Ont. K2E 7Y1	Tel: (613) 727-5692 Fax: (613) 727-5222 E-mail: phaulena@accutestlabs.com	Mrs. Lorna Wilson Mr. Peter Haulena
Agri-Food Laboratories Web site: www.agtest.com	503 Imperial Rd., Unit #1 GUELPH, Ont. N1H 6T9	Tel: (519) 837-1600 1-800-265-7175 Fax: (519) 837-1242 E-mail: lab@agtest.com	Mr. Dale Cowan Ms. Nora Wilson
Brookside Laboratories, Inc.	301 South Main St. NEW KNOXVILLE, Ohio, US 45871	Tel: (419) 753-2448 Fax: (419) 753-2949 E-mail: nfisher@blinc.com	Ms. Nicole Fisher Mr. Mark Flock
Soil and Nutrient Laboratory	University of Guelph P.O. Box 3650, 95 Stone Rd. W. GUELPH, Ont. N1H 2W1	Tel (519) 767-6226 Fax: (519) 767-6240 E-mail: vkerslak@lsd.uoguelph.ca	Ms. Virginia Kerslake
Stratford Agri Analysis (A Daco Laboratories Ltd.)	1131 Erie St., Box 760 STRATFORD, Ont. N5A 6W1	Tel: (519) 273-4411 1-800-323-9089 Fax: (519) 273-4411 E-mail: saa@dacolabs.com	Mr. Dale Peters Mr. Keith Lemp

There is no official accreditation in Ontario for tissue analysis, but all the accredited soil-testing labs are monitored for proficiency on tissue analyses.

Appendix E.
Vegetable Seed Suppliers

Abbot & Cobb
Brian Nungesser
11460 Fortune Circle W.
Palm Beach, Florida 33414 USA
Phone: 1-800-692-8055
Fax: (561) 795-2650

American Takii Inc.
Terry See
230 W. Oregon St.
Irrigon, OR 97844 USA
Phone: (541) 922-4197
Fax: (541) 922-2748

Boundary Garlic
Sonia Stairs/Henry Caron
Box 273
Midway, BC V0H 1M0
Phone: (250) 449-2152
Fax: (250) 449-2182
www.garlicfarm.ca

Crookham Co. Inc.
P.O. Box 520
Caldwell, ID 83606-0520 USA
Phone: (208) 459-7451
Fax: (208) 454-2108
E-mail: ccoinfo@crookham.com
www.crookham.com/

Dominion Seed House
P.O. Box 2500
Georgetown, ON L7G 5L6
Phone: (905) 873-3037
Fax: 1-800-282-5746
www.dominion-seed-house.com

Evergreen Y.H. Enterprises
(Asian Vegetables)
P.O. Box 17538
Anaheim, CA 92817 USA
Phone/Fax: (714) 637-5769
www.store.yahoo.com/evergreenseeds/index.html

Fred Fuller Seeds Ltd.
Distributor of Harris-Moran Seeds
(Merged with Ferry-Morse)
Fred Fuller
250 South Canal Bank Rd.
Kettleby, ON L0G 1J0
Phone: (905) 775-9696
www.harrismoran.com

Greygo Distributors
(Specialty Peppers, Gourds & Pumpkins)
Frank Peter
1442 Ridge Rd.
Harrow, ON N0R 1G0
Phone: (734) 502-8800
Fax: (734) 941-2081

Harris-Moran
(Merged with Ferry-Morse)
Dan Bailey, Fresh Market
P.O. Box 4938
Modesto, CA 95352 USA
Phone: (315) 655-3610
Fax: (315) 655-8098
E-mail: d.bailey@harrismoran.com
www.harrismoran.com/index.htm

Harris-Moran
(Merged with Ferry-Morse)
Bill Rankin, Processing
P.O. Box 4938
Modesto, CA 95352 USA
Phone: (717) 225-5557
Fax: (717) 225-5208
E-mail: b.rankin@harrismoran.com
www.harrismoran.com/index.htm

Hollar & Co.
Bob Nelson
P.O. Box 106
Rockyford, Colorado 81067 USA
Phone: (719) 254-7411
Fax: (719) 254-3539
www.hollarseeds.com/

Johnny's Selected Seeds
955 Benton Ave.
Winslow, Maine 04901-2601 USA
Main Line: (207) 861-3900
Fax: 800-437-4290
E-mail: info@johnnyseeds.com
www.johnnyseeds.com

Norseco Seeds
Robert Dumolin
2914 Labelle Rd.
Laval, QC H7P 5R9
Phone: 1-800-561-9693
Fax: 1-800-567-4594

Ontario Seed
Doug Yates /Jim Uffleman
P.O. Box 7
Waterloo, ON N2J 3Z9
Phone: (519) 886-0557
Fax: (519) 886-0605
E-mail: seeds@oscseeds.com
www.oscseeds.com

Ornamental Edibles
3272 Fleur De Lis Court
San Jose, CA 95132 USA
Phone: (408) 929-7333
Fax: (408) 929-5775
E-mail: info@ornamentaledibles.com
www.ornamentaledibles.com

Redwood City Seed Co.
Craig Dremann
P.O. Box 361
Redwood City, CA 94064 USA
Phone: (650) 325-7333
www.ecoseeds.com

Reed's Seeds
Don Reed
3334 N.Y.S. Rt. 215
Courtland, NY 13045-9440 USA
Phone: (607) 753-9095
Fax: (607) 753-9511

Richter's
Conrad Richter
357 Highway 47
Goodwood, ON L0C 1A0
Phone: (905) 640-6677
Fax: (905) 640-6641
www.richters.ca

Rispens Seeds Inc.
Ross Rispens
1357 Dutch American Way, P.O. Box 310
Beecher, IL 60401 USA
Phone: 1-888-874-0241
Fax: (708) 946-6115
www.rispensseeds.com

Rupp Seeds
George Wonnacott
135 Lancefield Place
Chatham, ON N7L 2M5
Phone: (519) 354-0206
Fax: (519) 354-0287
E-mail: gdwonnacott@primus.ca

Sakata Seed Inc.
Altee Burpee
Pennsylvania USA
Phone: (610) 825-7334
www.sakata.com

Seedway/Bejo
(Distributors of Bejo Varieties)
Brian D. Tregunno
259 Camelot Dr.
Burlington, ON L7L 2E9
Phone: (905) 637-7926
1-800-952-7333
Fax: (905) 637-7578

Seedway/Bejo
(Distributors of Bejo Varieties)
Matt Valk
R.R. # 4
Coldwater, ON L0K 1E0
Phone: (705) 835-3777
Fax: (705) 835-6898

Seed Works/Daehnfeldt
Frank Jonkman
17 Fern St.
Stratford, ON N5A 5K2
Phone: (519) 272-1200
Fax: (519) 272-1202
E-mail: fjonkman@seedworks-net.com
www.seedworksnet.com
www.daehnfeldt.com

Seminis (Asgrow Veg Seeds, Peto Seeds, Royal Sluis, Hungnong)
Ron Garton
613 Tomahawk Cres.
Ancaster, ON L9G 3T4
Phone: (905) 304-1795
Fax: (905) 304-3820
E-mail: ron.garton@svseeds.com

Seminis (Asgrow Veg Seeds, Peto Seeds, Royal Sluis, Hungnong)
Nancy Ouellet
Guelph, ON N1G 2E4
Phone: (519) 823-7963
Fax: (519) 823-7964
E-mail: nancy.ouellet@svseeds.com

Siegers Seed
Bob and Jake Hovius
18815 Dufferin
Bradford, ON L3Y 4V9
Phone: (905) 775-7912
Fax: (905) 775-3197
www.siegers.com

Stokes Seeds
Paul Banks
P.O. Box 10
St. Catherines, ON L2R 6R6
Phone: 1-800-263-7233
www.stokeseeds.com/cgi-bin/Stokes-Seeds.storefront

Stokes Seeds
Jim Robinson
P.O. Box 144
Rockton, ON L0R 1X0
Phone: (905) 715-8595
www.stokeseeds.com/cgi-bin/Stokes-Seeds.storefront

Sunseeds
Syd Hovius
R.R. #2, 18815 Dufferin
Newmarket, ON L3Y 4V9
Phone: (905) 775-6168
Fax: (905) 775-4912

Syngenta —Rogers Brand
Bob Kotch
573 Gardener Rd.
Horseheads, NY 14845 USA
Phone: (607) 739-0191
www.syngenta.com

Tomato Growers' Supply Company
P.O. 2237
Fort Myers, FL, 33902 USA
Phone: 1-888-478-7333
www.tomatogrowers.com

Tomato Solutions
Jim Dick
R.R. # 4, 23264 Mull Rd.
Chatham, ON N7M 5J4
Phone: (519) 354-3039
1-877-833-7358
Fax: (519) 354-2058
E-mail: jimdick@netrover.com

Totally Tomatoes
P.O. Box 1626
Augusta, GA 30903-1626 USA
Phone: (803) 663-0016
www.totallytomato.com/index.cfm

Vesey's Seeds
Bev Simpson
York, P.E.I. C0A 1P0
Phone: (902) 368-7333
Fax: (902) 566-1620
www.veseys.com

Vilmorin Inc.
Tom Gordon
P.O. Box 695
Trumansburg, NY 14886 USA
Phone: (905) 387-3959
Fax: (607) 387-3357
E-mail: vilmotg@aol.com

Appendix F.
Crop Insurance

The Canada-Ontario Crop Insurance Program is publicly funded by the Government of Canada and the Province of Ontario and delivered by AGRICORP. The Federal and Provincial governments each contribute 25% of the premium cost and 50% of the administrative costs. Both these contributions enable an Ontario grower to purchase insurance coverage at a substantially reduced cost.

The grower's payment is considered an operating expense for income tax purposes. Crop insurance offers protection against a broad range of production hazards, including excessive rain, hail, excessive drought, freeze, frost, excessive wind and certain insects and diseases.

For further information, please call AGRICORP's Customer Action Centre at 1-888-AGRI-999 (1-888-247-4999).

AGRICORP
1 Stone Rd. W.
Box 3660, Station Central
Guelph, Ontario N1H 8M4
Tel: (519) 826-3276
Fax: (519) 826-4118
Web site: www.agricorp.com

Ontario Crops Covered by a Crop Insurance Plan

Fruit Crops		
apples (fruit and/or trees)	cherries, sweet and sour	grapes (fruit and/or vines)
peaches	pears	plums
strawberries		
Vegetable Crops		
asparagus	green beans and wax beans (processing)	beets (processing)
broccoli	cabbages	carrots (fresh)
carrots (processing)	cauliflower	celery
cucumbers (processing)	lettuce	lima beans (processing)
parsnips	peas (processing)	peppers
potatoes	rutabagas	seed onions
set onions	Spanish onions	butternut squash (processing)
sweet corn (fresh)	sweet corn (processing)	tomatoes (processing)
tomatoes (fresh)		
General Crops		
coloured beans	white beans	canola
corn (grain and silage)	seed corn	forage
new forage seeding	honey	peanuts
popping corn	soybeans	spring grain
sugarbeets	sunflower	red spring wheat
wheat, winter	industrial hemp	
Tobacco		
black	flue-cured	

UNIVERSITY OF GUELPH

Main Campus
Guelph, N1G 2W1
(519) 824-4120
www.uoguelph.ca

Alfred College
Alfred, K0B 1A0
(613) 679-2218
www.alfredc.uoguelph.ca/

Kemptville College
Kemptville, K0G 1J0
(613) 258-8336
www.kemptvillec.uoguelph.ca

Ridgetown College
Ridgetown, N0P 2C0
(519) 674-1500
www.ridgetownc.on.ca

Department of Plant Agriculture
www.plant.uoguelph.ca

Department of Plant Agriculture Kettleby
1125 Woodchopper's Lane, R.R. # 1
Kettleby, L0G 1J0
(905) 775-3783

Department of Plant Agriculture, Simcoe
Box 587 Blue Line Rd.
Simcoe, N3Y 4N5
(519) 426-7127

Department of Plant Agriculture, Vineland
Box 7000, 4890 Victoria Ave. N.
Vineland Station, L0R 2E0
(905) 562-4141

Lab Services Division
www.uoguelph.ca/labserv/

Pesticide and Trace Contaminants
P.O. Box 3650, 95 Stone Rd., W.
Guelph, N1H 8J7
(519) 767-6200

Pest Diagnostic Clinic
(519) 767-6256

AGRICULTURE & AGRI-FOOD CANADA

Research Centres
Eastern Cereals and Oilseeds Research Centre
960 Carling Avenue, Ottawa, K1A 0C6
(613) 759-1952
http://res2agr.ca/ecorc/welcome.htm

Greenhouse and Processing Crops Research Centre
Harrow, N0R 1G0
(519) 738-2251
http://res2.agr.ca/harrow/

Southern Crop Protection and Food Research Centre
http://res2.agr.ca/london/pmrc/pmrchome.html

1391 Sandford St.
London, N5V 4T3
(519) 457-1470

Vineland Research Farm
4902 Victoria Ave. N.
Vineland, L0R 2E0
(905) 562-4113

Delhi Research Farm
Box 186 Schafer Rd.
Delhi, N4B 2W9
(519) 582-1950

CANADIAN FOOD INSPECTION AGENCY

www.cifa-acia.agr.ca

Regional Offices (Plant Protection)
Belleville
345 College St. E.
Belleville, K8N 5S7
(613) 969-3333

Hamilton
709 Main St. W., 101
Hamilton, L8S 1A2
(905) 572-4152

London
1200 Commissioners Rd. E., Unit 19
London, N5Z 4R3
(519) 691-1300

Niagara Falls
(Mailing address) R.R #1 P.O. Box #7
Niagara on the Lake, L0S 1J0
(Street address) 14154 Niagara River Parkway, Unit # 5
Niagara on the Lake
(905) 262-5331

Brantford
Federal Building, Dalhousie & Queen St, P.O. Box 637
Brantford, N3T 5P9
(519) 751-8157

Ottawa District
3 Observatory Crescent, Bldg. #3 Central
Experimental Farm, Ottawa, K1A 0C9
(613) 759-1571

Toronto Office
401 Champagne Dr., Unit 1
Downsview, M3J 2C6
(416) 954-1714

Windsor
441 University Ave. W., Suite 208
Windsor, N9A 5P9
(519) 252-7095

AGRICORP (Crop Insurance)

Customer Action Centre
1-888-AGRI-999 (1-888-247-4999)
P.O. Box 3660, Station Central
Guelph, Ontario N1H 8M4
www.agricorp.com

Appendix H.
Diagnostic Services

Samples for disease diagnosis, insect or weed identification, nematode counts and *Verticillium* testing can be sent to:

Pest Diagnostic Clinic
Laboratory Services Division
University of Guelph
95 Stone Rd. W.
Guelph Ont.ario, N1H 8J7
Tel (519) 767-6256
Fax (519) 767-6240
E-mail pdc@lsd.uoguelph.ca

Payment must accompany samples at the time of submission. Submission forms are available at www.uoguelph.ca/pdc.

Fee Schedule

Procedures	Price/ Sample
Plant Diseases	
Diagnosis not requiring plating	$25.00
Diagnosis requiring plating	$40.00
Turf diagnosis	$50.00
Bacterial identification using Biolog®	$95.00
Detection of virus using Transmission Electron Microscopy	$85.00
Detection of virus using ELISA (turnaround time = 5 working days; bulk rates are available)	$60.00
Weed Identification	$40.00
Insects	
Basic identification	$25.00
Identification requiring dissection and/or extensive keys	$40.00

Nematode and Verticillium Counts	Price/ Sample
Nematodes extracted from soil (Bearman Pan Method)	$25.00
Soybean cyst nematode (SCN) + egg count	$35.00
Nematodes extracted from roots	$60.00
Verticillium count	$60.00

Turnaround time:
Nematodes extracted from soil takes 7 or 8 days.
Nematodes extracted from roots takes 15 days.
Cyst count takes 3 or 4 days.
Charges will be applied to each sample submitted.

Payment: Please make cheque payable to the University of Guelph. VISA and Mastercard are also accepted. Please do not mail cash.

How to Sample for Nematodes

Soil

When to Sample

Soil and root samples can be taken at any time of the year that the soil is not frozen. In Ontario, nematode soil population levels are generally at their highest in May and June and again in September and October.

How to Sample Soil

Use a soil sampling tube, trowel or narrow-bladed shovel to take samples. Sample soil to a depth of 20–25 cm (8–10 in.). If the soil is bare, remove the top 2 cm (1 in.) prior to sampling. A sample should consist of 10 or more subsamples combined. Mix well. Then take a sample of ½–1 L (1 pint–1 quart) from this. No one sample should represent more than 2.5 ha (6.25 ac). Mix subsamples in a clean pail or plastic bag.

Sampling Pattern

If living crop plants are present in the sample area, take samples within the row and from the area of the feeder root zone (with trees, this is the drip line).

Number of Subsamples

Based on the total area sampled:

500 m^2 (5,400 ft^2)	10 subsamples
500 m^2–0.5 ha (5,400 ft^2–1.25 ac)	25 subsamples
0.5 ha–2.5 ha (1.25–6.25 ac)	50 subsamples

Roots

From small plants, sample the entire root system plus adhering soil. For large plants, 10–20 g (½–1 oz.) dig fresh weight from the feeder root zone and submit.

Problem Areas

Take soil and root samples from the margins of the problem area where the plants are still living. If possible, also take samples from healthy areas in the same field. If possible, take both soil and root samples from problem and healthy areas in the same field.

Sample Handling

Soil Samples

Place in plastic bags as soon as possible after collecting.

Root Samples

Place in plastic bags and cover with moist soil from the sample area.

Storage

Store samples at 5°C–10°C (40°C–50°F) and do not expose them to direct sunlight or extreme heat or cold (freezing). **Only living nematodes can be counted. Accurate counts depend on proper handling of samples.**

Submitting Plant for Disease Diagnosis or Identification

Sample Submission Forms

Forms can be obtained from your local Ontario Ministry of Agriculture and Food office. Carefully fill in all of the categories on the form. In the space provided, draw the most obvious symptom and the pattern of the disease in the field. It is important to include the cropping history of the area for the past 3 years and this year's pesticide use records.

Choose a complete, representative sample showing early symptoms. Submit as much of the plant as is practical, including the root system, or several plants showing a range of symptoms. For turfgrass, submit a 10–15 cm^2 piece of turf, including thatch and at least 5 cm of soil. Take the sample from the outside edge of a ring or patch, and include healthy and unhealthy turf, as well as the interface between. If symptoms are general, collect the sample from an area where they are of intermediate severity. **Completely dead material is usually inadequate for diagnosis**.

With plant specimens submitted for identification, include at least a 20–25-cm sample of the top portion of the stem with lateral buds, leaves, flowers or fruits in identifiable condition. Wrap plants in newspaper and put in a plastic bag. Tie the root system off in a separate plastic bag to avoid drying out and contamination of the leaves by soil. Do **NOT** add moisture, as this encourages decay in transit. Cushion specimens and pack in a sturdy box to avoid damage during shipping. Avoid leaving specimens to bake or freeze in a vehicle or in a location where they could deteriorate.

Delivery

Deliver to the Pest Diagnostic Clinic as soon as possible by first class mail or by courier at the beginning of the week.

Submitting Insect Specimens for Identification

Collecting Samples

Place dead, hard-bodied insects and spiders in vials or boxes and cushion with tissues or cotton. Place soft-bodied insects and caterpillars in vials containing alcohol. Do not use water, as this results in rot. Do not tape insects to paper or send them loose in an envelope.

Place live insects in a container with enough plant "food" to support them during transit. Be sure to write "live" on the outside of the container.

Appendix I.
Ontario Ministry of Agriculture and Food Staff

Specialty	Staff	Phone/Fax	E-mail
Brighton Resource Centre 95 Dundas St. E., RR #3 Brighton, ON K0K 1H0		General Tel: (613) 475-1630 Fax: (613) 475-3835	
IPM Systems Specialist	Margaret Appleby	Tel: (613) 475-5850	margaret.appleby@omaf.gov.on.ca
Delhi Southern Crop Protection and Food Research Centre Schafer Rd. Box 186 Delhi, ON N4B 2W9		General Tel: (519) 582-7220 Fax: (519) 582-4504	
IPM Specialist, Specialty Crops	Denise Beaton	Tel: (519) 582-7220, ext. 263	denise.beaton@omaf.gov.on.ca
Fergus Resource Centre RR#1, County Road 18, Wellington Place Fergus, ON N1M 2W3		General Tel: (519) 846-0941 Fax: (519) 846-8178	
Agroforestry Specialist	Todd Leuty	Tel: (519) 846-3390	todd.leuty@omaf.gov.on.ca
Harrow Greenhouse and Processing Crops Research Centre 2585 County Road 20 Harrow, ON N0R 1G0		General Tel: (519) 738-2251 Fax: (519) 738-4564	
Greenhouse Vegetable IPM Specialist	Gillian Ferguson	Tel: (519) 738-2251, ext. 406	gillian.ferguson@omaf.gov.on.ca
Weed Management – Horticulture Program Lead	Leslie Huffman	Tel: (519) 738-2251, ext. 499	leslie.huffman@omaf.gov.on.ca
Greenhouse Vegetable Specialist	Shalin Khosla	Tel: (519) 738-2251, ext. 405	shalin.khosla@omaf.gov.on.ca
Kemptville Resource Centre Box 2004, Concession Rd. Kemptville, ON K0G 1J0		General Tel: (613) 258-8295 Fax: (613) 258-8392	
Emerging Crops Specialist	Scott Banks	Tel: (613) 258-8359	scott.banks@omaf.gov.on.ca
Agroforestry Specialist	Dave Chapeskie	Tel: (613) 258-8302	dave.chapeskie@omaf.gov.on.ca
Field Crops, IPM Program Lead – Bilingual	Gilles Quesnel	Tel: (613) 258-8250	gilles.quesnel@omaf.gov.on.ca
Lindsay Resource Centre 322 Kent St. W Lindsay, ON K9V 2Z9		General Tel: (705) 324-6125 Fax: (705) 324-1638	
Forage Specialist	Joel Bagg	Tel: (705) 324-5856	joel.bagg@omaf.gov.on.ca
London Resource Centre 667 Exeter Road London, ON N6E 1L3		General Tel: (519) 873-4070 Fax: (519) 873-4062	
Apple Specialist	John Gardner	Tel: (519) 873-4084	john.gardner@omaf.gov.on.ca
New Liskeard 280 Armstrong St., Box 4070, New Liskeard, ON P0J 1P0		General Tel: (800) 461-6132 Fax: (705) 647-7993	
Agriculture and Rural Representative	Daniel Tasse	Tel: (705) 647-2085	daniel.tasse@omaf.gov.on.ca
Ridgetown Resource Centre Agronomy Building, Ridgetown College, Box 400, Main St. E. Ridgetown, ON N0P 2C0		General Tel: (519) 674-1690 Fax: (519) 674-1564	
Soil Management Specialist – Field Crops	Adam Hayes	Tel: (519) 674-1621	adam.hayes@omaf.gov.on.ca
Pathologist – Field Crops Program Lead	Albert Tenuta	Tel: (519) 674-1617	albert.tenuta@omaf.gov.on.ca
Soil Management Specialist – Horticulture	Anne Verhallen	Tel: (519) 674-1614	anne.verhallen@omaf.gov.on.ca
Vegetable Crops Specialist	Elaine Roddy	Tel: (519) 674-1616	elaine.roddy@omaf.gov.on.ca
Vegetable Crops Specialist	Janice LeBoeuf	Tel: (519) 674-1699	janice.leboeuf@omaf.gov.on.ca
Entomology, Field Crops Program Lead	Tracey Baute	Tel: (519) 674-1696	tracey.baute@omaf.gov.on.ca
Simcoe Resource Centre P.O. Box 587, Blueline Rd & Hwy #3 Simcoe, ON N3Y 4N5		General Tel: (519) 426-7120 Fax: (519) 428-1142	
New Crop Development Specialist	Mike Columbus	Tel: (519) 426-4509	mike.columbus@omaf.gov.on.ca
Berry Crop Specialist	Pam Fisher	Tel: (519) 426-2238	pam.fisher@omaf.gov.on.ca

Appendix I.
Ontario Ministry of Agriculture and Food Staff (Continued)

Specialty	Staff	Phone/Fax	E-mail
Ginseng and Medicinal Herbs Specialist	Jan Schooley	Tel: (519) 426-4323	jan.schooley@omaf.gov.on.ca
Pome Fruit IPM Specialist	Kathryn Carter	Tel: (519) 426-4322	kathryn.carter@omaf.gov.on.ca
Stratford Resource Centre 581 Huron St. Stratford, ON N5A 5T8		General Tel: (519) 271-0280 Fax: (519) 273-5278	
Alternate Production Systems Specialist	Brian Hall	Tel: (519) 271-0083	brian.hall@omaf.gov.on.ca
Cereals Specialist	Peter Johnson	Tel: (519) 271-8180	peter.johnson@omaf.gov.on.ca
Biosolids Specialist	Michael Payne	Tel: (519) 271-4496	michael.payne@omaf.gov.on.ca
Soil Fertility Specialist	Keith Reid	Tel: (519) 271-9269	keith.reid@omaf.gov.on.ca
Soybean Specialist	Horst Bohner	Tel: (519) 271-5858	horst.bohner@omaf.gov.on.ca
Vineland – HRIO, University of Guelph Box 7000 4890 Victoria Ave. N Vineland Station L0R 2E0		General Tel: (905) 562-4141 Fax: (905) 562-3413	
Greenhouse Floriculture Specialist	Wayne Brown	Tel: (905) 562-4141, ext. 179	wayne.brown@omaf.gov.on.ca
Greenhouse Floriculture IPM Specialist	Graeme Murphy	Tel: (905) 562-4141, ext. 106	graeme.murphy@omaf.gov.on.ca
Vineland Resource Centre Adv. Serv. Building, Box 8000, 4890 Victoria Ave. North Vineland Station, ON L0R 2E0		General Tel: (905) 562-4147 Fax: (905) 562-5933	
Tender Fruit and Grape Specialist	Ken Slingerland	Tel: (905) 562-1639	ken.slingerland@omaf.gov.on.ca
Nutrient Management Horticulture Crops Program Lead	Donna Speranzini	Tel: (905) 562-1170	donna.speranzini@omaf.gov.on.ca
Entomology, Horticulture Program Lead	Hannah Fraser	Tel: (905) 562-1674	hannah.fraser@omaf.gov.on.ca
Fresh Market Quality Program Lead	Dr. Jennifer R. DeEll	Tel: (905) 562-1693	jennifer.deell@omaf.gov.on.ca
Tender Fruit and Grape IPM Specialist	Neil Carter	Tel: (905) 562-3833	neil.carter@omaf.gov.on.ca
Woodstock Resource Centre Box 666, Hwy. #59 N Woodstock, ON N4S 7Z5		General Tel: (519) 537-6621 Fax: (519) 539-5351	
Nutrient Management Field Crops Program Lead	Christine Brown	Tel: (519) 537-8305	christine.brown@omaf.gov.on.ca
Guelph OMAF 1 Stone Rd. W. Guelph, ON N1G 4Y2			
Director Crop Technology	Bill Ingratta	Tel: (519) 826-3151 Fax: (519) 826-3567	bill.ingratta@omaf.gov.on.ca
Manager, Greenhouse, Agroforestry and Specialty Crops	Annette Anderson	Tel: (519) 826-3286 Fax: (519) 826-3567	annette.anderson@omaf.gov.on.ca
Manager, Horticulture Technology	Hugh Berges	Tel: (519) 826-3288 Fax: (519) 826-3567	hugh.berges@omaf.gov.on.ca
Manager, Horticulture Crops	John Finlay	Tel: (519) 826-6941 Fax: (519) 826-3567	john.finlay@omaf.gov.on.ca
Manager, Field Crops	Brent Kennedy	Tel: (519) 826-3257 Fax: (519) 826-3567	brent.kennedy@omaf.gov.on.ca
Marketing and Communications Officer	Cathy Bartolic (acting)	Tel: (519) 826-3150 Fax: 826-3259	cathy.bartolic@omaf.gov.on.ca
Apiary Specialist	Doug McRory	Tel: (519) 826-3595 Fax: (519) 826-4964	doug.mcrory@omaf.gov.on.ca
Product Development Specialist	Kelly Ward	Tel: (519) 826-4094 Fax: (519) 826-4964	kelly.ward@omaf.gov.on.ca
Vegetable Crops Specialist	Kristen Callow	Tel: (519) 826-4963 Fax: (519) 826-4964	kristen.callow@omaf.gov.on.ca
On-Farm Food Safety Program Lead	Sandra Jones	Tel: (519) 826-3289 Fax: (519)826-4964	sandra.jones@omaf.gov.on.ca
Organic Crop Production Program Lead	Hugh Martin	Tel: (519) 826-4587 Fax: (519)826-4964	hugh.martin@omaf.gov.on.ca

Appendix I.
Ontario Ministry of Agriculture and Food Staff (Continued)

Specialty	Staff	Phone/Fax	E-mail
Minor Use Coordinator	Jim Chaput	Tel: (519) 826-3539 Fax: (519) 826-4964	jim.chaput@omaf.gov.on.ca
Potato Specialist	Dr. Eugenia Banks	Tel: (519) 826-3678 Fax: (519) 826-4964	eugenia.banks@omaf.gov.on.ca
University of Guelph 50 Stone Rd. E. Guelph, ON N1G 2W1		General Tel: (519) 824-4120	
Turfgrass Specialist Guelph Turfgrass Institute 328 Victoria Rd. S., R.R. # 2 Guelph, ON N1H 6H8	Pam Charbonneau	Tel: (519) 824-4120, ext. 2597 Fax: (519) 766-1704	pamela.charbonneau@omaf.gov.on.ca
Pathologist – Horticulture Crops Program Lead Edmund Bovey Building	Michael Celetti	Tel: (519) 824-4120, ext. 8910 Fax: (519) 767-0755	michael.celetti@omaf.gov.on.ca
Nursery Crops Specialist Edmund Bovey Building	Jennifer Llewellyn	Tel: (519) 824-4120, ext. 2671 Fax: (519) 767-0755	jennifer.llewellyn@omaf.gov.on.ca
Nutrition – Horticulture Program Lead Land Resource Science, Richards Building	Christoph Kessel	Tel: (519) 824-4120, ext. 2480 Fax: (519) 824-5730	christoph.kessel@omaf.gov.on.ca
Weed Management Field Crops Program Lead Crop Science Building	Mike Cowbrough	Tel: (519) 824-4120, ext. 2580 Fax: (519) 763-8933	mike.cowbrough@omaf.gov.on.ca
Applied Research Coordinator – Field Crops Crop Science Building	Ian McDonald	Tel: (519) 824-4120, ext. 6707 Fax: (519) 763-8933	ian.mcdonald@omaf.gov.on.ca
Corn Industry Program Lead Crop Science Building	Greg Stewart	Tel: (519) 824-4120, ext. 4865 Fax: (519) 763-8933	greg.stewart@omaf.gov.on.ca

Agricultural Information Contact Centre

Provides province-wide, toll-free technical and business information
to commercial farms, agri-businesses and rural businesses.

1 Stone Rd. W.
Guelph ON N1G 4Y2

1-877-424-1300 or (519) 826-4047
Fax: (519) 826-7610
E-mail: ag.info@omaf.gov.on.ca

Guelph – Government Information Centre

1 Stone Rd. W.
Guelph ON N1G 4Y2
Staff Directories — Phone 1-888-466-2372 or (519) 826-3100

Metric Units

Linear Measures (length)		
10 millimetres (mm)	=	1 centimetre (cm)
100 centimetres (cm)	=	1 metre (m)
1,000 metres	=	1 kilometre (km)
Square Measures (area)		
100 m X 100 m = 10,000 m^2	=	1 hectare (ha)
100 ha	=	1 square kilometre (km^2)
Cubic Measures (volume)		
Dry Measure		
1,000 cubic millimetres (mm^3)	=	1 cubic centimetre (cm^3)
1,000,000 cm^3	=	1 cubic metre (m^3)
Liquid Measure		
1,000 millilitres (mL)	=	1 litre (L)
100 L	=	1 hectolitre (hL)
Weight-Volume Equivalents (for water)		
(1.00 kg) 1,000 grams	=	1 litre (1.00 L)
(0.50 kg) 500 g	=	500 mL (0.50 L)
(0.10 kg) 100 g	=	100 mL (0.10 L)
(0.01 kg) 10 g	=	10 mL (0.01 L)
(0.001 kg) 1 g	=	1 mL (0.001 L)
Weight Measures		
1,000 milligrams (mg)	=	1 gram (g)
1,000 g	=	1 kilogram (kg)
1,000 kg	=	1 tonne (t)
1 mg/kg	=	1 part per million (ppm)
Dry–Liquid Equivalents		
1 cm^3	=	1 mL
1 m^3	=	1,000 L

Calculating Parts per Million (ppm)		
1 ppm	=	1 g active ingredient per 1,000 L water
Handy Metric Conversion Factor		
litres per hectare x 0.4	=	litres per acre
kilograms per hectare x 0.4	=	kilograms per acre

Application Rate Conversions

Metric to Imperial (Approximate)		
litres per hectare x 0.09	=	gallons per acre
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre
Imperial to Metric (Approximate)		
gallons per acre x 11.23	=	litres per hectare (L/ha)
quarts per acre x 2.8	=	litres per hectare (L/ha)
pints per acre x 1.4	=	litres per hectare (L/ha)
fluid ounces per acre x 70	=	millilitres per hectare (mL/ha)
tons per acre x 2.24	=	tonnes per hectare (t/ha)
pounds per acre x 1.12	=	kilograms per hectare (kg/ha)
ounces per acre x 70	=	grams per hectare (g/ha)

Liquid Equivalents

Litres/Hectare		*Approximate Gallons/Acre*
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

Dry Weight Equivalents

Grams or Kilograms / Hectare		*Ounces or Pounds /Acre*
100 grams	=	1 1/2 ounces
200 grams	=	3 ounces
300 grams	=	4 1/4 ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1 1/4 pounds
2.00 kilograms	=	1 3/4 pounds
2.50 kilograms	=	2 1/4 pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3 1/2 pounds
5.00 kilograms	=	4 1/2 pounds
6.00 kilograms	=	5 1/4 pounds
7.50 kilograms	=	6 3/4 pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11 1/2 pounds
15.0 kilograms	=	13 1/2 pounds

Metric Conversions		
5 mL	=	1 tsp
15 mL	=	1 tbsp
28.5 mL	=	1 fl. oz

Conversion Tables — Metric to Imperial

Length		
1 millimetre (mm)	=	0.04 inch
1 centimetre (cm)	=	0.40 inch
1 metre (m)	=	39.40 inches
1 metre (m)	=	3.28 feet
1 metre (m)	=	1.09 yards
1 kilometre (km)	=	0.62 mile
Area		
1 square centimetre (cm^2)	=	0.16 square inch
1 square metre (m^2)	=	10.77 square feet
1 square metre (m^2)	=	1.20 square yards
1 square kilometre (km^2)	=	0.39 square mile
1 hectare (ha)	=	107,636 square feet
1 hectare (ha)	=	2.5 acres
Volume (dry)		
1 cubic centimetre (cm^3)	=	0.061 cubic inch
1 cubic metre (m^3)	=	1.31 cubic yards
1 cubic metre (m^3)	=	35.31 cubic feet
1,000 cubic metres (m^3)	=	0.81 acre-foot
1 hectolitre (hL)	=	2.8 bushels
Volume (liquid)		
1 millilitre (mL)	=	0.035 fluid ounce
1 litre (L)	=	1.76 pints
1 litre (L)	=	0.88 quart
1 litre (L)	=	0.22 gallon (Imp.)
1 litre (L)	=	0.26 gallon (U.S.)
Weight		
1 gram (g)	=	0.035 ounce
1 kilogram (kg)	=	2.21 pounds
1 tonne (t)	=	1.10 short tons
1 tonne (t)	=	2,205 pounds
Pressure		
1 kilopascal (kPa)	=	0.15 pounds/in^2
Speed		
1 metre per second	=	3.28 feet per second
1 metre per second	=	2.24 miles per hour
1 kilometre per hour	=	0.62 mile per hour
Temperature		
°F	=	(°C X $^9/_5$) + 32

Conversion Tables — Imperial to Metric

Length		
1 inch	=	2.54 cm
1 foot	=	0.30 m
1 yard	=	0.91 m
1 mile	=	1.61 km
Area		
1 square foot	=	0.09 m^2
1 square yard	=	0.84 m^2
1 acre	=	0.40 ha
Volume (dry)		
1 cubic yard	=	0.76 m^3
1 bushel	=	36.37 L
Volume (liquid)		
1 fluid ounce (Imp.)	=	28.41 mL
1 pint (Imp.)	=	0.57 L
1 gallon (Imp.)	=	4.55 L
1 gallon (U.S.)	=	3.79 L
Weight		
1 ounce	=	28.35 g
1 pound	=	453.6 g
1 ton	=	0.91 tonne
Pressure		
1 pound per square inch	=	6.90 kPa
Temperature		
°C	=	(°F – 32) x $^5/_9$

Abbreviations

%	= per cent (by weight)	km	= kilometre
ai	= active ingredient	km/h	= kilometres per hour
AP	= agricultural powder	kPa	= kilopascal
cm	= centimetre	L	= litre
cm^2	= square centimetre	m	= metre
DG	= dispersible granular	m^2	= square metre
DP	= dispersible powder	mL	= millilitre
E	= emulsifiable	mm	= millimetre
e.g.	= for example	m/s	= metres per second
EC	= emulsifiable concentrate	SC	= sprayable concentrate
F	= flowable	SP	= soluble powder
g	= gram	t	= tonne
Gr	= granules, granular	W	= wettable (powder)
ha	= hectare	WDG	= water dispersible granular
kg	= kilogram	WP	= wettable powder

Emergency and First-Aid Procedures for Pesticide Poisoning

For a major spill, a theft or a fire involving a pesticide call the Ministry of the Environment at **1-800-268-6060**.

For pesticide poisonings and pesticide injuries call the **Poison Information Centre:**

Toronto	1-800-268-9017
Ottawa (Bilingual)	1-800-267-1373
Hearing Assistance (TTY)	1-877-750-2233

PREVENT ACCIDENTS

- **Read the label.** Follow all the precautions the label recommends. Read the First Aid section of the label BEFORE you begin to handle any pesticide.
- **Make sure that someone knows** what pesticides you are working with and where you are.
- **Keep a file of labels and product Material Safety Data Sheets (MSDS) for the pesticides you use**. Make sure everyone knows where to find this in case of an emergency.
- **Post emergency numbers near all telephones.**
- **Keep clean water, paper towels, extra gloves and clean coveralls close by** in case you spill pesticide on yourself.

If someone has been working with pesticides and you see any possible symptoms of pesticide poisoning or injury, take emergency action immediately.

IF AN ACCIDENT OR POISONING HAPPENS

- Protect yourself from injury first.
- Stop the exposure to the pesticide. Move the victim away from the contaminated area.
- Check the 4 basic facts — identify the pesticide, the quantity, the route of entry and time of exposure.
- Call an ambulance or the Poison Information Centre.
- Start first aid. This is **not** a substitute for professional medical help.
- **Provide the label, MSDS sheet or container to emergency personnel** at the scene — or take it with you to the hospital. Do not transport pesticide containers in the passenger compartment of the vehicle.

FIRST AID

If a pesticide comes in contact with skin:

- remove all contaminated clothing; wash skin thoroughly with lots of soap and warm water
- dry skin well and cover with clean clothing or other clean material.

If pesticide comes in contact with eyes:

- hold eyelids open wash the eyes with clean running water for 15 minutes or more.

If pesticide was inhaled:

- move the victim to fresh air and loosen tight clothing
- give artificial respiration if the victim is not breathing.

Do not breathe in the exhaled air from the victim — you could also be poisoned.

If a pesticide was swallowed:

- **call the Poison Information Centre IMMEDIATELY.**

Emergency numbers are listed at the front of each Bell telephone directory.

For information, or to obtain copies of this or any other ministry publication please:

call 1-888-466-2372 from within Ontario, (519) 826-3700 from outside the province or OMAF's TTY line at (519) 826-7402 for the hearing impaired, email your request to *products@omaf.gov.on.ca*, or visit OMAF's Web site at *www.omaf.gov.on.ca*.

A complete list of all OMAF products and services, and order forms, are available on the Web site. Orders can be faxed to (519) 826-3633 or mailed to Government Information Centre, OMAF, 1 Stone Road West, Guelph, Ontario N1G 4Y2.

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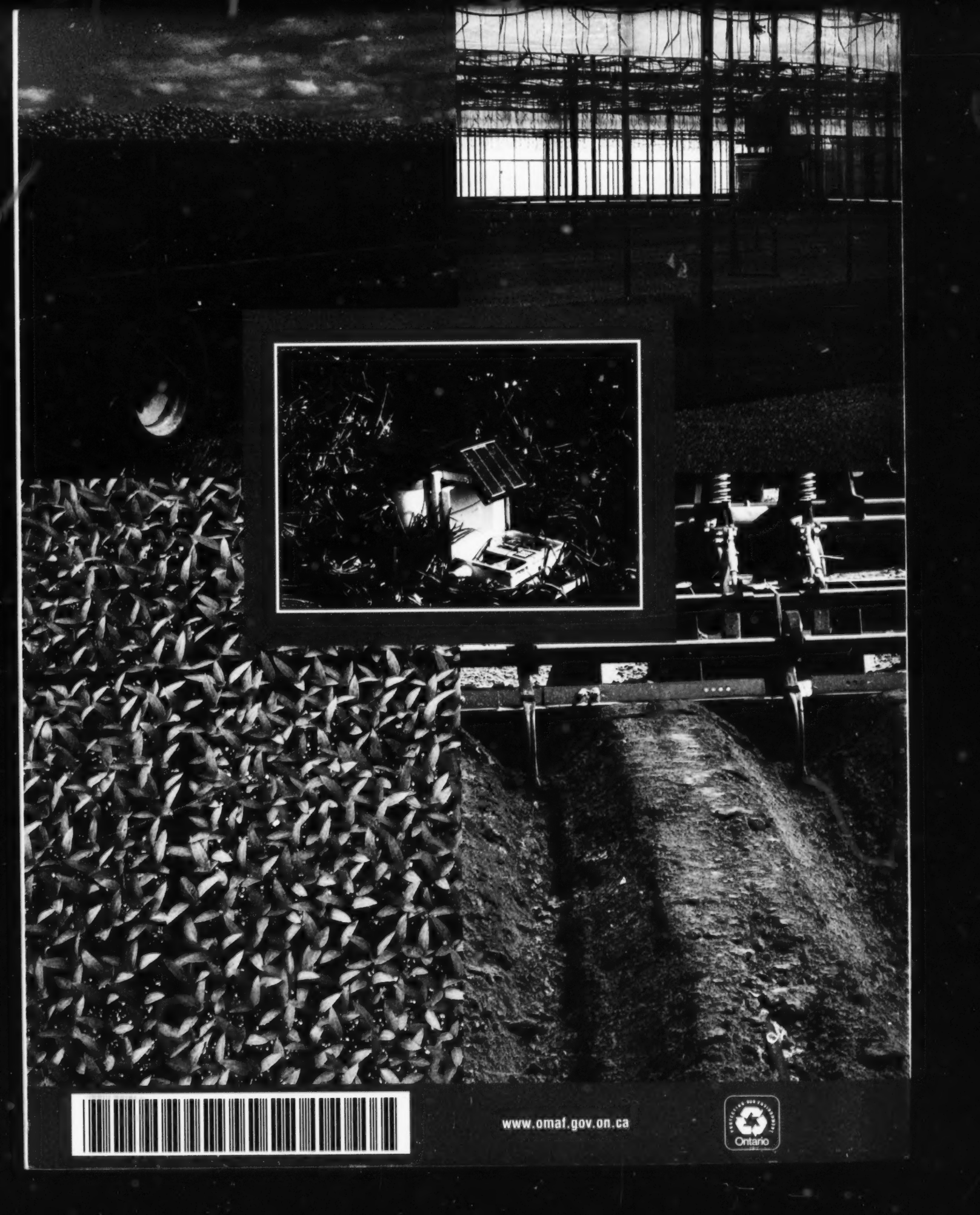

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